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MACHINERY

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SPECIAL TOOLS USED IN THE MAKING OF DENTAL CHAIRS

By CARROLL ASHLEY*

IN order to more clearly explain the special tools to be described in this article it will be necessary to briefly describe the construction of the dental chair for which the tools are used. A dental chair is rather a complicated piece of mechanism, which perhaps is best proved by the fact that in case repairs are necessary, even skilled mechanics, inexperienced in this class of work, are usually unable to remedy the defects, and the chair has to be sent back to the factory. Some parts of the chair described in the following, in fact, are so complex that only a trained expert can assemble them.

At first thought it may be assumed that a dental chair is no more complicated than a barber's chair. However, there is a vast difference between the two. The barber's chair must be made to rise and fall easily for two or three reclining positions, and perhaps rotate clear around. The dental chair must meet a great many more requirements. It must be perfectly rigid, and its levers must be easily accessible to the operator, making it possible to adjust it to any position; the chair must be built to fit the tall and the short, the stout and the thin. Sometimes it is necessary to etherize the patient, in which case the back of the chair must be placed lower than the front, so as to drop the patient's head. This necessitates a "compensating back," that is, a back which will lengthen out as the patient is lowered to the reclining position.

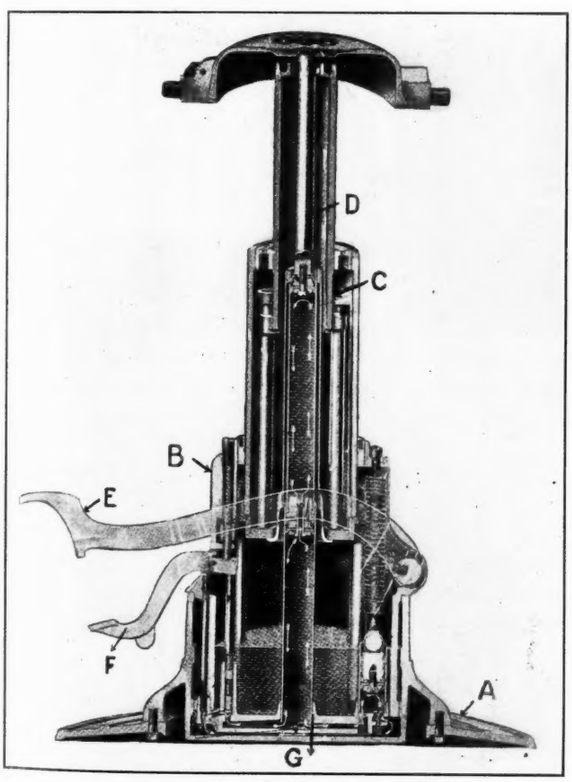

Fig. 1. Section of Base of Dental Chair

Fig. 1 shows a section of the lower part of a dental chair, this part being termed the base. The principal parts are the floor plate *A*, the cylinder *B*, and the outer and inner tubes *C* and *D*, which are all of cast iron. The main raising and lowering levers *E* and *F* are also made of cast iron. The part *G* at the very bottom of the reservoir is a brass casting carrying the different valves. The center of this casting carries the telescoping tubes into which oil is pumped for the operation of the chair.

The base ring is sufficiently large to support the chair without fastening it to the floor, although holes are provided for this purpose. It also serves as a reservoir for the oil used in the pump for raising and lowering the chair. This raising and lowering mechanism consists of a pump and plunger operated by the foot by means of the main lever *E*. The operation of this lever forces the oil from the reservoir into

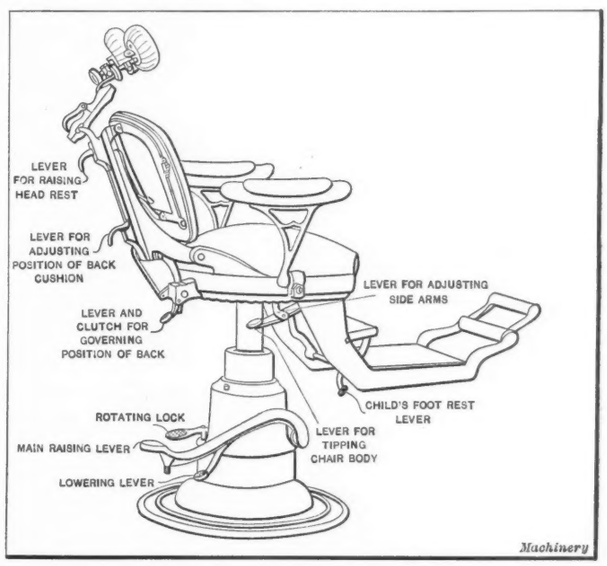
LEVER FOR RAISING HEAD REST
LEVER FOR ADJUSTING POSITION OF BACK CUSHION
LEVER AND CLUTCH FOR GOVERNING POSITION OF BACK
LEVER FOR ADJUSTING SIDE ARMS
CHILD'S FOOT REST LEVER
ROTATING LOCK
MAIN RAISING LEVER
LOWERING LEVER
LEVER FOR TIPPING CHAIR BODY
Machinery

Fig. 2. General Outline of Dental Chair

the telescopic tubes and against the lower end of the rod and plunger, as indicated in Fig. 1. The plunger is provided with leather packing, fitting the tube closely. Due to the telescoping construction a large range of vertical positions can be obtained. When the chair is to be lowered, lever *F* is pressed, which opens a valve and allows the oil to flow out of the telescopic tubes back into the reservoir. The sudden closing of the valve by withdrawing the foot ordinarily has a tendency to give the patient a jolt. In this particular construction this is obviated, however, by a retarding device which causes the chair to come to rest in so smooth a manner that it is hardly possible to notice the exact moment when motion ceases. Several round guide-rods are provided to prevent the telescopic tubes from turning and to give strength and rigidity to the mechanism. The lower ends of the cast-iron tubes slide on these guide-rods, the tubes being provided with lugs for this purpose.

Fig. 2 shows the general features of a dental chair in outline, and Figs. 3 and 4 show the main parts of the base as they appear immediately before being assembled.

Tools used in the Making of a Dental Chair

A number of interesting tools which the writer has designed for building the chair described will now be dealt with. Figs. 5 to 13, inclusive, illustrate drilling and reaming attachments for drilling and reaming two to four holes simultaneously.* The attachments are used on a J. E. Snyder & Son drill press. The shafts and spindles of the attachment are of tool steel with ball thrust bearings. The line engravings Figs. 10 to 13 show the principal arrangements. These attachments differ in their details on account of the location of the holes to be drilled. In the four-spindle arrangement

* Address: 625 Esperanza St., Los Angeles, Cal.

* See also MACHINERY, October, 1906, "Three-Spindle Drilling Attachment."

shown in Fig. 8, for example, there is just room enough for the train of driving gears, while in Fig. 9 there is ample room for the gearing. In all cases, however, the spindles in the attachments have about the same speed as that of the main spindle of the drill press.

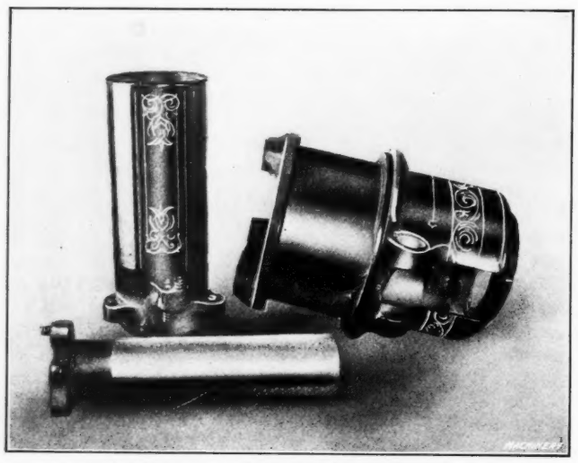

Fig. 3. The Cylinder, Outer and Inner Tube of Chair before assembling

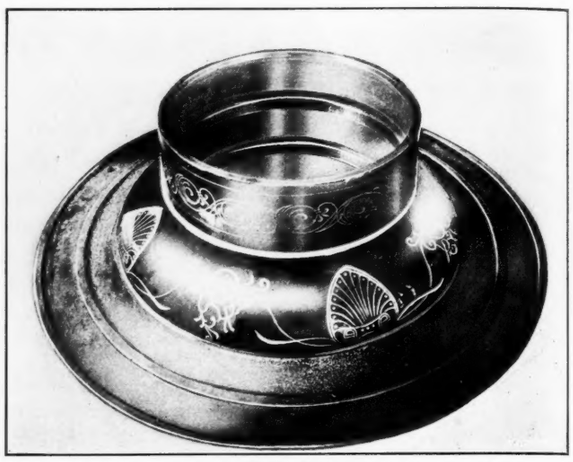

Fig. 4. Floor-plate of Chair, showing Bearings on Inside

It is not altogether essential that the drills or reamers be of the same length, except in the case of the two-spindle attachment, Figs. 5 and 10, where it was found necessary to sharpen them to the same length, because otherwise the drills and reamers would cause the jig holding the work to wind or twist. It is understood, of course, that the work operated on by these drilling attachments is held in jigs, and the drills are guided by bushings. On all the spindles of these attachments a spiral oil groove is cut the full length of the bearing, so that when the spindles revolve, the oil is driven upwards, and thorough lubrication of the bearing is obtained.

These attachments were not all designed to fit one drill press, but as several machines of the same make were available, each press had its own attachments which could easily be removed when the drill press was to be used for other work. The bracket *A* and the carrier *B* shown in the line engravings Figs. 10 and 12 are of cast iron, and when bolted together provide a very stiff construction. The bracket is not, as might be supposed, bolted fast to the drill press head, but is fastened by two cap-screws which take the place of the regular tie-bolts that hold the lower ends of the gibs to the head. The holes for these screws are shown in Fig. 8 at the upper end of the bracket. The bracket is gibbed to the column.

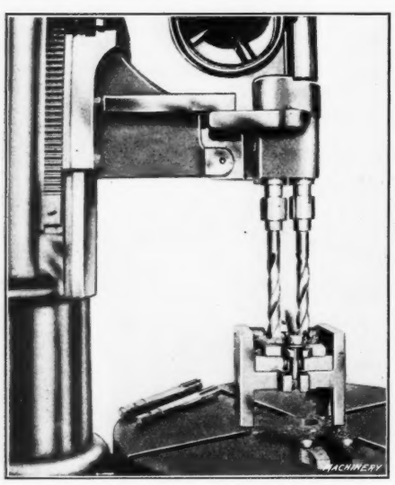

Fig. 5. A Two-spindle Drilling Attachment

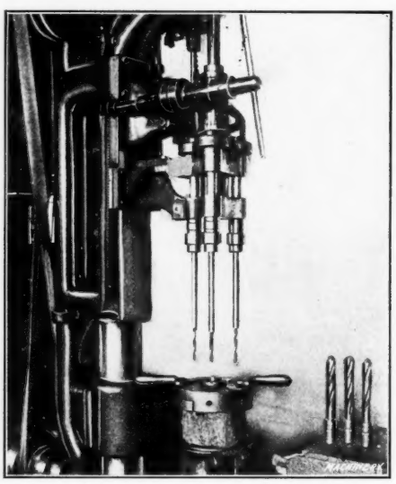

Fig. 6. Three-spindle Drilling Attachment

Fig. 7. Four-spindle Drilling Attachment

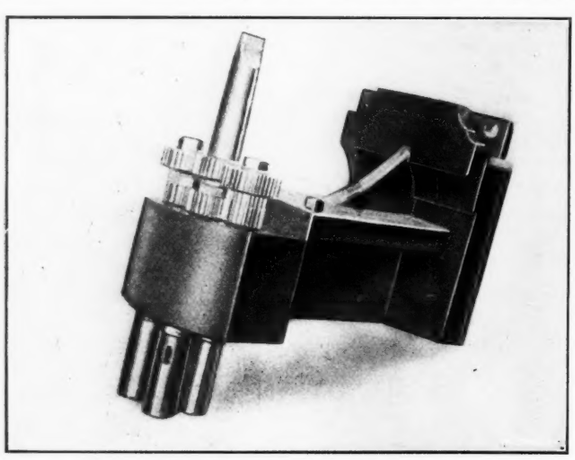

Fig. 8. Compact Four-spindle Drilling Attachment

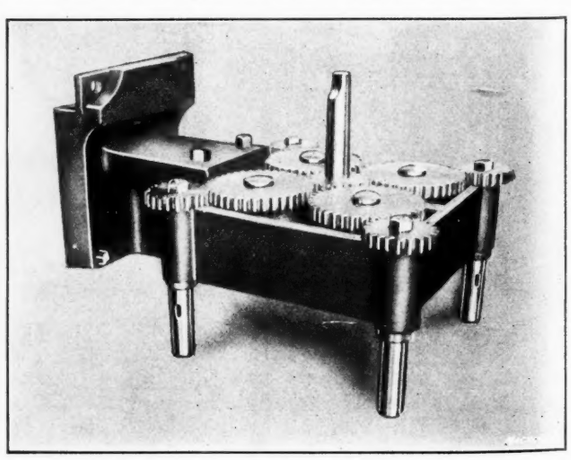

Fig. 9. Attachment shown in Fig. 7 with Gear Covers removed

It will be seen in Fig. 12 that the thrust of all four spindles is taken by a ball bearing at *C* seated in the center of the spindle carrier *B*. The idler gears shown at *D* are separate gears pinned together, thus practically making a solid gear. The pitch circles of the gears only are indicated in the illustrations.

When removing the attachments from the drill press, the cap-screws *E*, Fig. 11, are taken out, permitting the attachment to slip off the ways. The driving gear and shank remain in the drill spindle after the removal of the attachment, and are driven out the same as a drill.

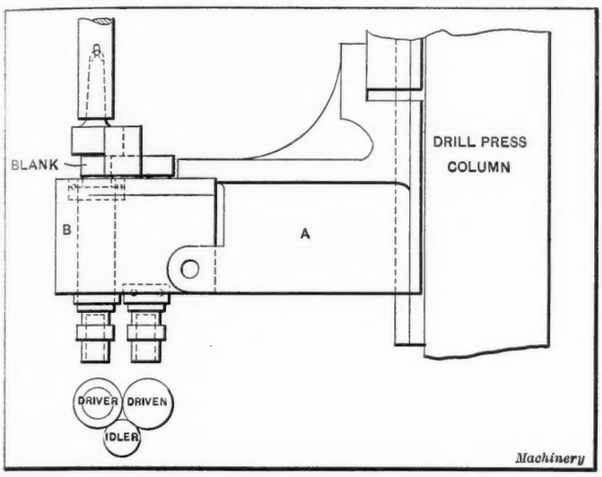

Fig. 10. General Design of Attachment in Fig. 5

Fig. 5 shows the two-spindle attachment in use drilling two pieces at one time, the pieces being shown in the foreground. It will be noted that the gears are properly encased to prevent accident to the operator. In Fig. 11 a three-spindle attachment is shown. There are two sets of lugs on the pieces which are drilled with this attachment which necessitates two sets of drills and reamers, one set being about 16 inches long. As indicated in Fig. 11, the lower part of the driving spindle *F*, in this instance, has to be unscrewed to separate the shank that is held in the drill press spindle from the fixture itself. Fig. 6 shows another three-spindle attachment constructed especially for "extension" drilling. Figs. 8 and 12 show an especially powerful four-spindle drilling attachment. Fig. 7 shows a four-spindle attachment which drills the four holes in the base ring for bolting it to the floor. As there is no reaming to be done in this case, the spindles are arranged to carry taper shank drills. The drills are not removed except when sharpened. In Fig. 9 the gear guard is removed showing the gear arrangement. The main casting is not as heavy as it appears to be in the illustration, as it is designed with webs as indicated in Fig. 13.

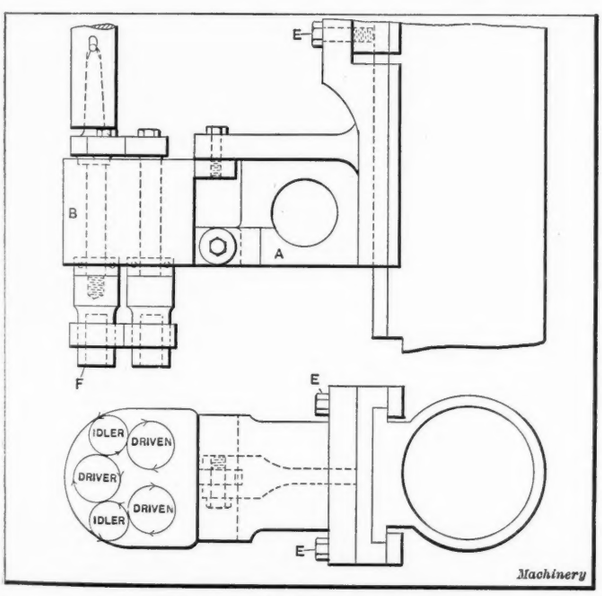

Fig. 11. Three-spindle Drilling Attachment

A Reaming Attachment

In the outer tube mentioned in the description of the chair, there are three lugs which must be reamed for the guide-rods. This reaming operation has been done by hand for years, a good sixteenth inch of metal on the diameter having been removed in lugs ⅞ inch thick. Naturally this was slow work, and the fixture shown in Fig. 14 was therefore designed by the writer. By means of this device the time is cut down to one-quarter of that previously required. A countershaft, not shown in Fig. 14, is hung in the ceiling and carries on the end of the shaft a pair of miter gears which drive the vertical universal telescopic shaft shown. This shaft, in turn, drives a pair of miter gears in a cast-iron box or cage having a handle on each side. In reaming the tube, the operator places it in a vise, inserts the reamer, swings the fixture in front of it, attaches the "ball-chuck" on the end of the projecting horizontal shaft to the reamer, as shown, and puts his foot on a lever under the bench which shifts the belt on the countershaft from the loose to the driving pulley. This starts the reamer, and the operator merely has to push it right through the work. When the hole is reamed through, he lifts his foot from the lever and a spring pulls the belt back to the loose pulley.

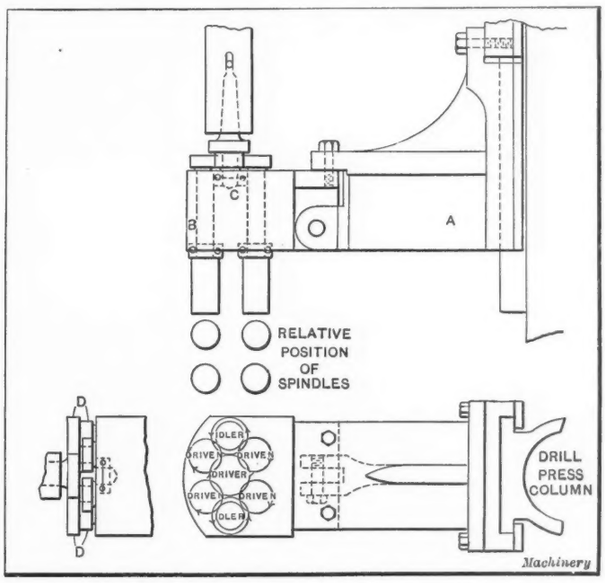

Fig. 12. Design of Four-spindle Attachment shown in Fig. 8

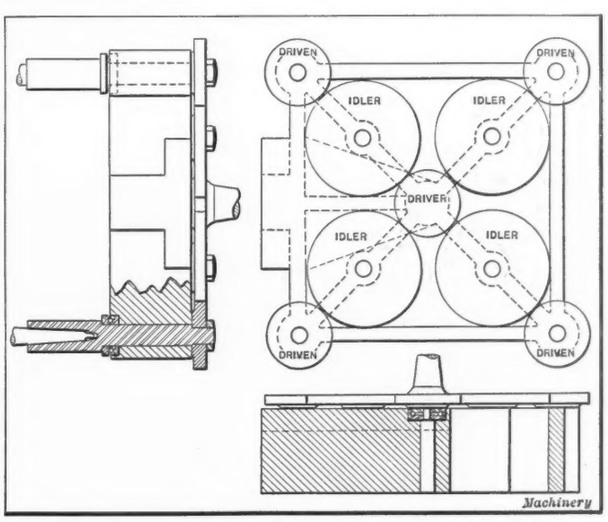

Fig. 13. General Design of Attachment shown in Figs. 7 and 9

A Compound Lathe Tool

Figs. 15, 16 and 17 show a tool for a turning operation in the lathe. As shown in Fig. 3, there are two bearings on the cylinder which are machined to size and must be true. The

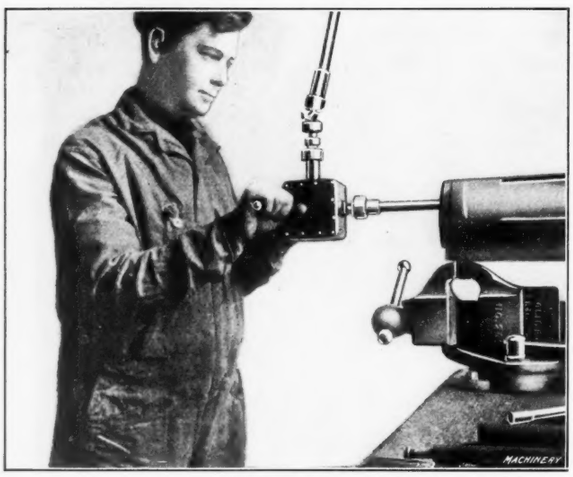

Fig. 14. A Reaming Attachment

bearing near the center of the cylinder is faced to a square shoulder. This operation was originally done on a vertical milling machine, but too much time was consumed and the

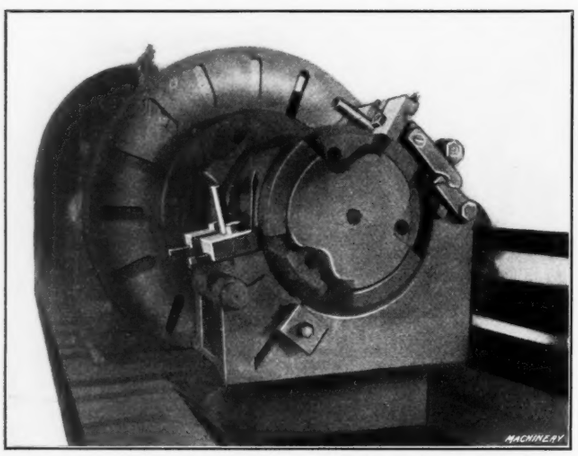

Fig. 15. Turning Tool for Cylinders of Dental Chair with Cylinder in Position for Turning

results were unsatisfactory. To improve this method, the toolpost slide of an old lathe that stood idle was removed, and the fixture shown in the illustrations was permanently

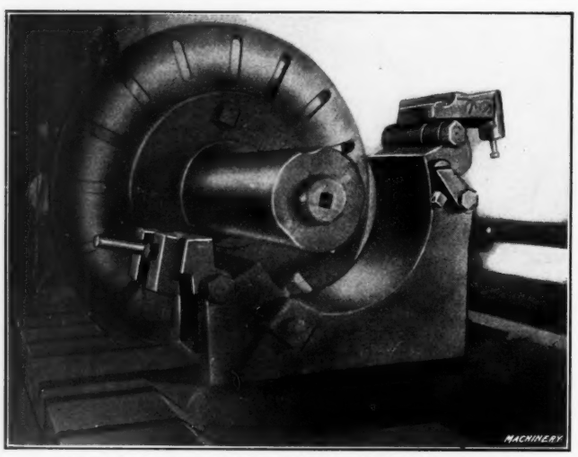

Fig. 16. Turning Tool for Cylinders of Dental Chair with Cylinder removed

dovetailed in its place. The body *A*, Fig. 17, is of cast iron and on it are mounted three pairs of Novo high-speed steel tools. The two roughing tools shown at *B* are stationary and are clamped in slots on the sides of the body. The second roughing tools *E* are mounted in a hinged holder *C*, which is thrown in when the carriage has been moved back after the first roughing tools have finished their cut. The locking device *D* holds these tools in position. After the roughing tools *E* have finished their cut, the finishing tools *F* are thrown in and the two bearings finished simultaneously.

Fig. 16 shows the cylinder removed and the second roughing tools and the finishing tools thrown out. The cylinder is securely held on the holder or arbor shown bolted to the faceplate of the lathe. One end of the cylinder fits the tapered shoulder near the faceplate and the other end is held central by three conical plugs driven out together by the socket screw shown in the center of the outer end of the arbor. The end of this screw is pointed to a 60-degree angle and the ends of the three plugs are correspondingly tapered.

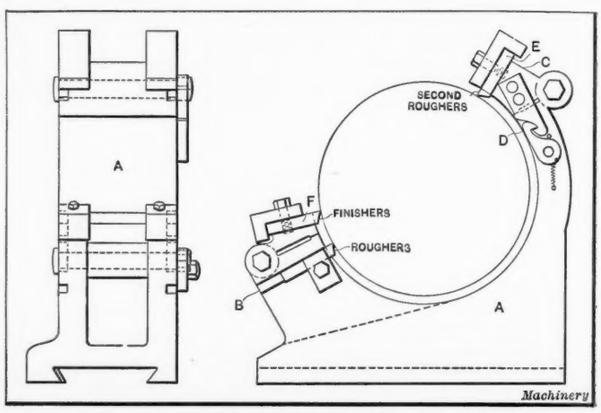

Fig. 17. General Design of Tool shown in Figs. 15 and 16

Fig. 15 shows the cylinder in position with the tools thrown in, and with a piece held onto the bottom of the cylinder into which the tailstock center is forced. When the turning was done on the vertical milling machine nine or ten pieces only could be completed in a day. With the arrangement shown, eighteen or twenty pieces constitute an average day's work.

A Special Boring Tool

As shown in Fig. 4, the base ring of the chair has three ribs on the inside. The top and lower one of these ribs con-

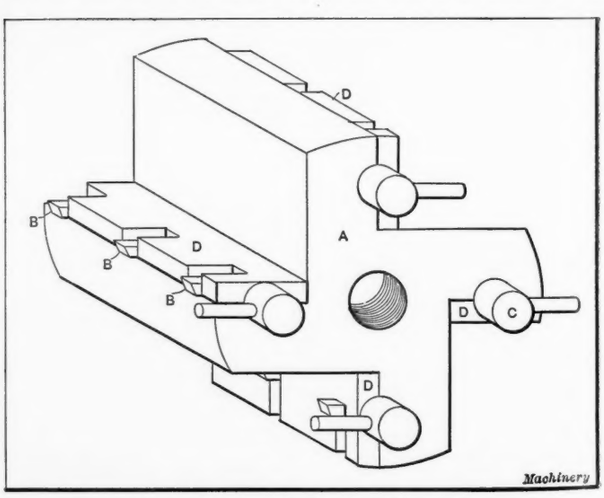

Fig. 18. A Multiple Boring Tool for Roughing and Finishing

stitute bearings for the cylinder, and it is on these bearings that the chair rotates. The central rib is for the locking device to bear upon. All three of these bearings had been milled out with a gang mill until the boring tool shown in Fig. 18 was designed. In this illustration the general outline of the tool is shown. The body *A* is of cast iron, having a hole in the center bored and threaded to fit the spindle of a large Becker vertical milling machine. On the four wings of the tool are mounted four shafts, each carrying three cutting tools *B*. The shafts are held in their seats by the covers *D*, the retaining screws of which are not shown. The

shafts are free enough in their bearings to be turned by the small levers shown at their ends; this turning motion, limited by the depths of the slots in the covers *D*, throws the tools in or out of their working position, as desired. Two sets of these tools are roughing tools and two are finishing tools.

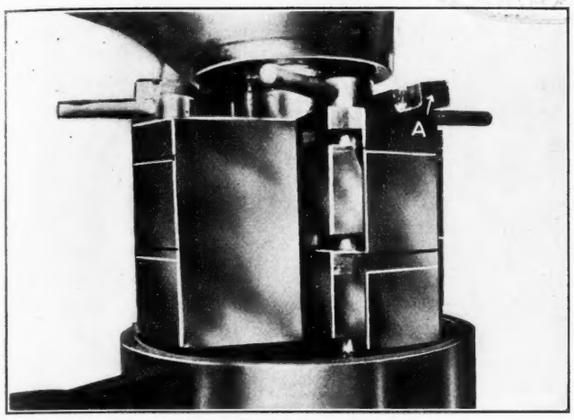

Fig. 19. General Appearance of Tool in Fig. 18

When in operation, both the roughing and finishing tools are turned in and the whole tool is lowered into the work to a point where the tools are just above the respective bearings to be machined. The two sets of roughing tools are then turned outward and the tool is fed downward while rotating. After having roughed all three bearings at once, the tool is withdrawn a little more than the thickness of the bearings, the finishers are thrown outward, and the tool is again fed down until the two facing tools, not shown in Fig. 18, but indicated at *A* in Fig. 19, face off the top edge of the casting. When the tools are taken out to be ground, a gage is used in re-setting them. This tool works very smoothly and quietly.

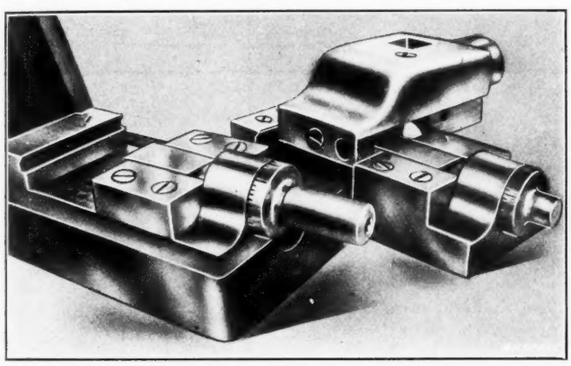

Fig. 20. The Device in Fig. 21 in its Case, and in Use

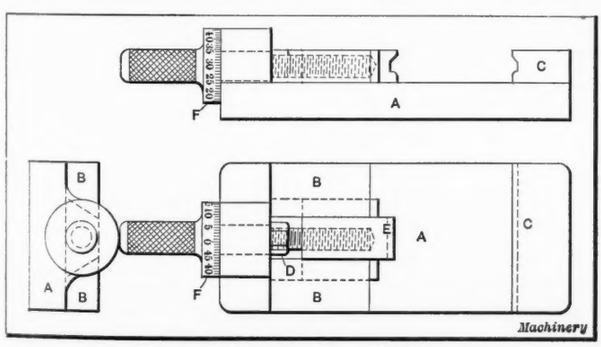

Fig. 21. A Micrometer Measuring Device

A Micrometer Measuring Device

The tool shown in Fig. 21 was made to caliper the beveled edges of the slides used on the back of the dental chair. This device is much more satisfactory than a solid gage because the proximity of the pieces to the correct size can be determined, the size of the piece being read off in thousandths of an inch. On the casting *A* are fastened gibs *B* in the opening between which is a sliding member *E*, notched as shown to fit the piece to be calipered. The member *C* is the anvil of the tool, the same as in a micrometer. The lock-nut *D* prevents end motion of the screw while driving part *E* in or out. The thimble *F* has fifty graduations and the lead-screw twenty threads to the inch, thus giving readings to 0.001 inch. Fig. 20 shows the finished gage in its case and also with a slide to be calipered in it.

Inner Tube Frosting Device

In Fig. 23 is shown a frosting device which was pronounced by both the superintendent and the manager as one which could not be made to work. The experiments with the device were, therefore, carried on in secret, and after a "try-out" a tube was presented to the authorities which was frosted even better than could be done by hand. Fig. 22 shows a sectional view of the arrangement. A cast-iron bracket *A* is fitted to a Landis grinder, near the spindle which carries the emery wheel. On this bracket is mounted shaft *B* which carries a worm-wheel on one end and a member *C* on the other, the latter being connected to the shaft by a

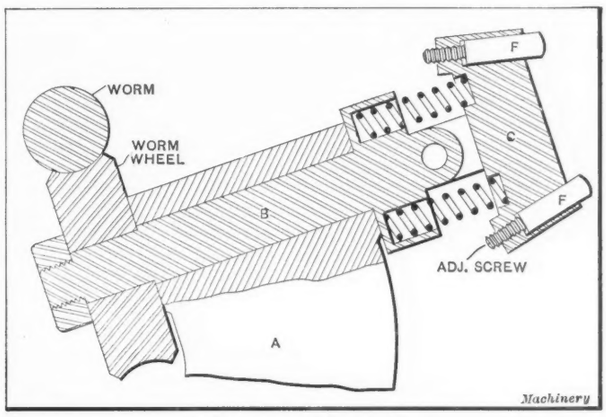

Fig. 22. A Frosting Device

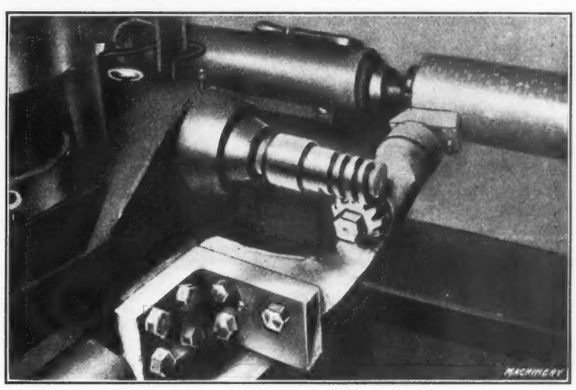

Fig. 23. Frosting Device in Operation

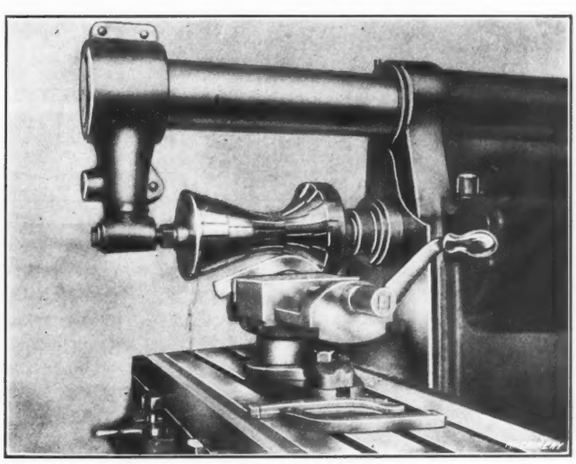

Fig. 24. A Special Built-up Milling Cutter

knuckle-joint as shown. This member is held central in relation to the shaft by springs. Diametrically opposite each other are placed two oilstones *F* which operate upon the work to be frosted. The screws behind the oilstones provide for adjustment as the stones wear away. The work is rotated and travels back and forth the same as if an emery wheel were working on it. The spindle *B* and head *C* carrying the oilstones are also rotated, being driven by a worm connected to the emery-wheel spindle of the grinder. The worm-wheel has eleven teeth, so that the speed of the shaft carrying the oilstones is reduced to one-eleventh of the regular speed of the grinding-wheel spindle. The work is rotated at the maximum speed. The grinder head is set over fifteen degrees so that only one oilstone bears on the work at once. The work, of course, is first ground very smooth. It then travels once across and back and is then completed. Kerosene is used as a lubricant. In Fig. 23 the device is shown at work.

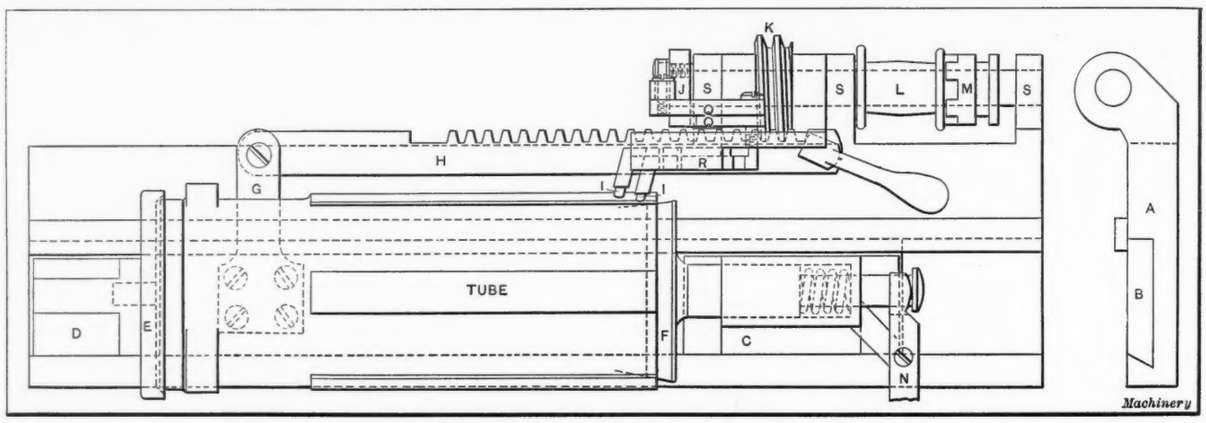

Fig. 25. Plan View of Automatic Frosting Device

A Large Formed Milling Cutter

Fig. 24 shows a large inserted tooth milling cutter for milling one edge of the "back-bar" of the chair. This cutter is constructed in five sections and is keyed onto a special arbor so that all the teeth are staggered. The cutter blades are made of Novo steel and are held in their respective seats by tapered pins in slots between all the blades. In making this cutter, the various sections were first keyed on a mandrel so that the rows of teeth were even, and were then backed off the same as a formed tooth cutter, after which the teeth were removed and hardened. In this way it is possible to take out the teeth at any time and sharpen them on their faces. The cutter bodies are of cast iron, except the center one, which is made of Novo steel and without inserted teeth. An idea of the size of the cutter may be obtained by noting that it is shown in Fig. 24 on a No. 4 Cincinnati milling machine.

Another Frosting Device

The outer tube shown in Fig. 3 has four bearings on its periphery. Just before the tubes are assembled these bearings are frosted. Previous to the time when the writer designed the device shown in plan and side elevation in Figs. 25 and 26, respectively, this frosting was done by hand. The mechanism operating the different members, which makes this device semi-automatic, is not shown. The end view shows simply the form of the base casting. The bed *A* has three lugs *S*. A sliding member *B*, nearly as long as the bed, carries a headstock *C*, footstock *D* and bracket *G*. On the footstock is a disk *E*, and on the headstock a disk *F*, which serve as centers for swinging the outer tube. The spindle of the headstock is fastened to the center *F* and is released by the hand lever *N*. The coil spring shown holds the tube on the centers while the device is in operation. Lugs *S* carry a shaft on which is keyed a clutch *M*, worm *K*, and crank disk *J*. The driving pulley *L* is loose on the shaft. On each side of worm *K* are the lugs of the swinging bracket *R*, which carries the mechanism governing the action of the oilstones *I*. In Fig. 26 the bracket *R* is shown more clearly. The slides *Q* travel in T-slot openings on the inner side of *R*, these slides carrying the oilstones. The two members that form the quadrant *O* are fastened together to make one unit. As the shaft is turned, the crank disk *J* drives crank *P* and imparts a reciprocating motion to the quadrant *O*, which, in turn, moves slides *Q* back and forth.

Assume that a tube is to be frosted. After placing the tube on its centers, the operator pulls a lever, throwing in clutch *M*. The oilstones simultaneously begin to reciprocate, and

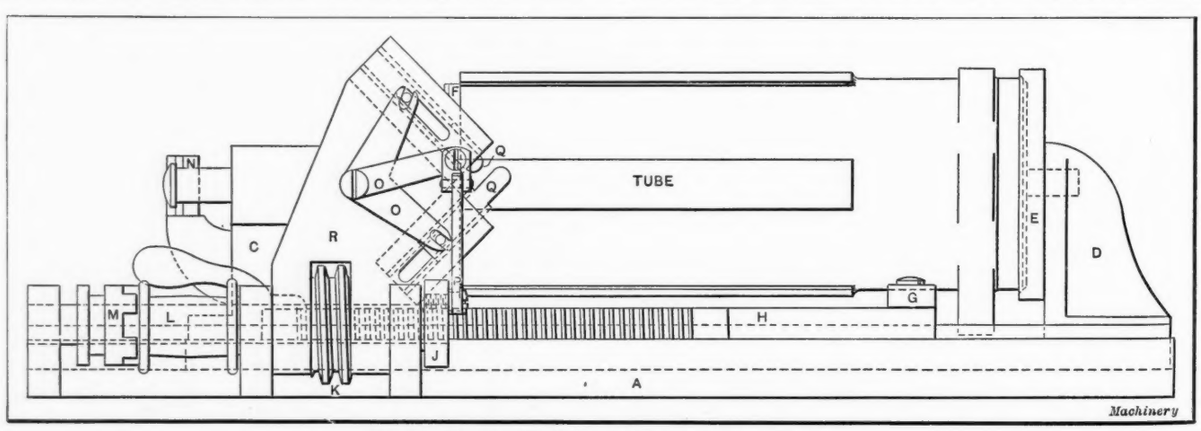

Fig. 26. Elevation (Back View) of Device shown in Fig. 25

slide *B* will move lengthwise of the bed, operated by worm *K* meshing in rack *H*. When the stones have reached the end of the bearing of the tube, bracket *R* moves outward and away from the tube, rack *H* flies out of mesh, and slide *B* returns to its starting place by the action of a weight. As the slide returns to its starting place, it strikes a bellcrank under the bed, not shown, throwing out the clutch. Bracket *R* remains away from the work until the clutch is pulled in again, which the operator does after having indexed the tube for the next track. In designing a device of this kind, the writer found it good practice to merely draw an outline and make separate sketches of the different mechanisms, as sometimes the whole character of the machine must be changed.

DRAWING A FLANGED AND TAPERED CYLINDRICAL SHELL*

By JOSEPH V. WOODWORTH†

In the production of cylindrical shells from flat stock, the construction of the tools and the number of operations or steps in their development depend entirely upon what the ultimate shape is to be. Thus, when it is desired to produce a straight cylindrical shell of a depth not exceeding, say, twice the diameter, the first operation may be accomplished in a combination blanking and drawing die, which will cut the blank and draw it to a height almost equal to the diameter. If a flange is left around the shell, the die can be used in a single-action press, a rubber spring barrel being used to create pressure on the blank. If no flange is left on the shell, a double-action press is used and all of the blank area worked into the shell, the metal being drawn through the die, and the shell stripped on the under edge of the drawing die at the commencement of the return stroke. After this first operation, two, or at the most, three redrawing operations, each accomplishing an approximately equal reduction in diameter and increase in depth, will attain the desired result. In such work, the evolution of the shape and the dimensions can usually be planned accurately without trouble before starting the construction of the tools, and the blanking die can be made to size with the certainty that just the right amount of stock will be contained in the blank to produce a shell of the required form, diameter and depth.

Fig. 1. The Successive Operations in the Production of a Flanged and Tapered Cylindrical Shell

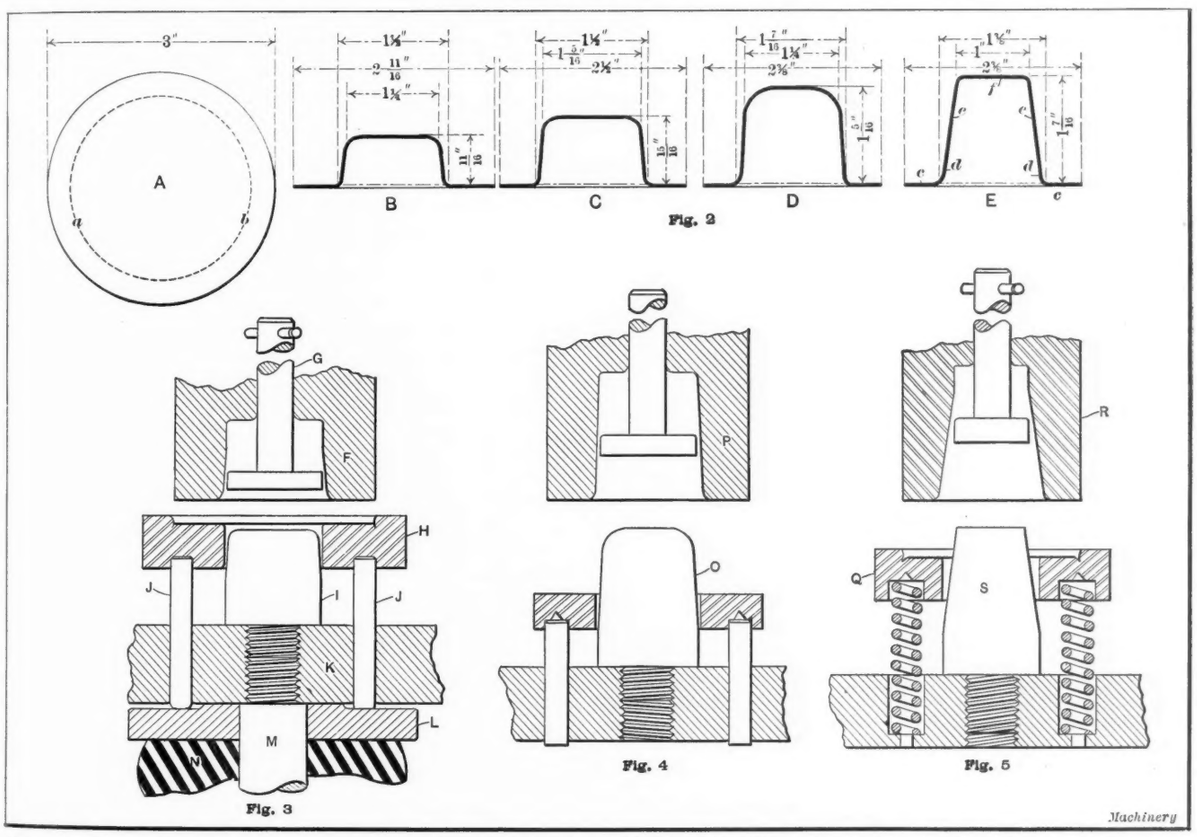

Fig. 2. Development, Evolution and Dimensions of a Flanged and Tapered Cylindrical Shell. Fig. 3. The Drawing Punch and Die for the Cups shown at B and C, Fig. 2. Fig. 4. Redrawing Punch and Die for Operation shown at D. Fig. 5. The Finishing Punch and Die for Operation shown at E

When the shell height does not exceed the shell diameter, only a slight variation will take place in the thickness of the wall, and the final thickness will not differ materially from the original blank thickness, that is, if the metal drawn is perfectly soft to commence with and the product of each drawing operation is annealed before reducing. If the holes in the drawing dies are lapped, the punches fitted properly and given just sufficient taper to allow the shell to be stripped without collapsing the rim, an elegant surface will be attained and the shell diameter will be true.

In drawing tapered cylindrical shells with flanges, the requirements for the construction of the dies and the evolution of the shell shapes are different. When the taper in the finished shell is considerably acute in comparison with the height and diameter, the desired result can only be accomplished as shown in Figs. 1 to 5 inclusive. To attain these

* For additional information on drawing dies and kindred subjects, see the following articles previously published in MACHINERY: "Dies for Drawing a Deep Steel Shell," January, 1912; "Drawing Rounding Covers in One Operation," November, 1911; "Press Tools for an Aluminum Shell," October, 1911; "The Multiple Plunger Press," August, 1911; "A Wiring Die," June, 1911; "Drawing a Cold-Rolled Steel Shell," "Shape of Drawing Edges in Sheet Metal Drawing Dies," April, 1911; "Cartridge Making—1 and 2," March and April, 1911; "Drawing Deep Cylindrical Shells," February, 1911; "Drawing Deep Cylindrical Shells," December, 1910; "Tools for Drawing Seamless Automobile Lamp Hoods," February, 1910; "Dies and Methods for Making Watch Crowns," December, 1909, engineering edition; "Drawing Dies for Hollow Rivets," October, 1909; "Sheet Metal Drawing," August, 1908; "The Drawing of Cartridge-Cases for Quick-Firing Guns," January, 1906; "Dies for Making Tin Nozzles," May, 1905; "A Combination Cutting, Drawing and Knurling Die," January, 1905; "A Quintuple Combination Die for Producing Five Drawn and Embossed Tin Shells in One Operation," March, 1904; "Some Suggestions for Die Making," January, 1904; "Dies for Square Tin Boxes," February, 1901; "A Combination Die and a Piercing Die," November, 1900; "Combination Drawing and Forming Die," October, 1900; see also MACHINERY'S Reference Book, No. 26, "Modern Punch and Die Construction."

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results, it is first necessary to bring the blank into a cylindrical shape, the area of which will just equal that of the metal required in the finished shell. When trouble is experienced in drawing tapered shells, it is almost invariably caused through the die-maker endeavoring to generate the acute taper in the first operation, or to draw it directly from the flat blank. When this practice is followed the shell is either split at the bottom, or waves and wrinkles are formed in the wall of the shell which cannot be removed. Another frequent cause of trouble lies in having a surplus of metal in the shell, and the consequent inability to distribute it in the finishing operation or to return it to the flange from which it was drawn.

When the proper amount of metal is contained in the shell form as shown at *D*, Fig. 2, with slightly tapering walls, a succeeding operation of reforming—not drawing or reducing through friction—will shape the cylindrical shell to the desired taper. The reason for this practice is that in drawing a straight cylindrical shell or even one slightly tapering, the metal is confined at all times during the process of drawing, between the die and punch surfaces, making the inception of wrinkles impossible and the flow of metal equal and constant during the entire operation. When the depth to be drawn is quite shallow as compared with the shell diameter, even acute tapers can sometimes be accomplished in one operation.

Fig. 1 shows clearly the result of each operation, while Fig. 2 illustrates the various steps necessary to develop the final form completely. In Fig. 2, *A* is the blank, 3 inches in diameter by 0.032 inch thick—No. 20 Brown & Sharpe gage. The blank was cut in a plain blanking die in an automatic press. *B* is the result of the second operation, and is accomplished in the die shown in Fig. 3, as is also the redrawing operation *C*, the die remaining unchanged, except that a thinner locating pad and blank-holder was substituted for the one shown at *H*. In Fig. 3, *F* is the drawing die, *G* the shell ejector, *H* the blank-holder and locater, *I* the drawing punch, *J* two of five spring barrel pins, *K* the die-bolster, *L* one of the two spring barrel-washers, *M* the barrel stud, and *N* the rubber spring barrel, only a section of which is shown, it being circular, 4 inches in diameter by 6 inches high with a 1-inch hole through it.

At *C* in Fig. 2, it will be noticed that an increase of ¼ inch in height and 1/16 inch in top diameter is attained. At *D* the height is increased to 1 5/16 inch—a gain of 3/8 inch—and at *E* the shell is completed to a height of 1 7/16 inch, the smallest diameter being 1 inch and the largest 1 3/8 inch with a flange diameter of 2 3/8 inches. The dotted line *a b* at *A* in Fig. 2, shows the amount of metal drawn from the blank to form the entire cone of the shell at *E*.

Fig. 4 shows the tools used for accomplishing the operation shown at *D* in Fig. 2. A spring buffer, not shown, is used as in Fig. 3, and the cup *C*, Fig. 2, is located on the punch *O*, the die *P* descending and drawing the cup to the shape shown at *D*.

In the finishing punch and die shown in Fig. 5, no drawing of the metal takes place, the displacement of the wall of the shell and reshaping alone being accomplished. Only a slight description is necessary to understand the operation of the die shown in Fig. 5. The shell *D* is located in a seat in the holder *Q*, and the die *R* descends, holding the flange of the shell tightly between the faces of *Q* and *R*, while the punch *S* forms the shell into the tapered shape shown at *E*. At the bottom of the stroke, pressure occurs on all surfaces of the shell, shaping it to a tapered and cylindrical form.

In the evolution of the finished shell the following changes take place in the wall and flange thickness: At *c* (see *E* Fig. 2) the metal is reduced to 0.030 inch, at *d* to 0.022 inch, at *e* to 0.018 inch, and at *f* to 0.021 inch. It was necessary to anneal the shell twice, after the first draw and after the third or redrawing operation. To secure satisfactory results the annealing has to be accomplished without producing a surface scale, as the scale would prevent the attainment of smoothness and accuracy in the finished product.

Thin lard oil was used as a lubricant during the first two drawing operations, and then the shells were run dry and clean through the last two operations. No fractured shells came through, and the tools produced a large quantity of the shells which were used in molding fixtures for brass articles reinforced with cement. The drawing pads, punches and spring buffer pins used in the dies shown in Figs. 3 and 4, were made of steel, the other parts being made of cast iron. For the finishing die, Fig. 5, steel was used throughout for all the working parts, and the pad and die surfaces were hardened and lapped to a finish.

In drawing tapered shells of the type shown in Figs. 1 and 2, in which a uniform thickness of wall throughout is not demanded, a slight insufficiency of metal in the product of the next to the last operation is best, as the finishing tool can then stretch the metal so as to bring the surface and diameter perfectly smooth and true.

* * *

EFFICIENCY IN CYLINDRICAL GRINDING*

By F. B. JACOBS†

Anyone who has followed the progress made in cylindrical grinding for the last ten or fifteen years, will admit that the present-day grinding machine, which owes a large part of its success to the modern grinding wheel, has been one of the prime factors in cutting down the cost of production, by furnishing a rapid and efficient method for accurately finishing the component parts of high-grade machinery. To follow the development of the grinding machine from the crude toolpost grinder of the early sixties, to the present-day self-contained grinder capable of finishing such work as chilled rolls for steel mills, piston-rods for marine engines, and an endless variety of work of like nature that heretofore was finished by the slow process of turning, would without doubt be very interesting. For the present, however, let us merely consider a few of the methods employed by up-to-date concerns for obtaining the maximum output from the grinding machine.

The thoroughly up-to-date machinist who looks over the advertisements in the leading trade papers has probably noticed that the manufacturers of grinding machines are not at all bashful in their claims for the efficiency of their machines, and that several makers of grinding wheels play a close second. But notwithstanding all that has been published concerning the efficiency of grinding machines and grinding wheels, the average shop foreman seems to be perfectly satisfied as long as the operator of the grinding machine turns out work that is nicely finished, in just a little shorter time than it could be done by obsolete methods.

There are several reasons for this condition of affairs: One is that the average shop foreman served his time before the introduction of modern grinding; another is that the majority of grinding machine operators have made themselves believe that because they are employed on accurate work, they should be a long time in doing it. Among other reasons are the improper selection of wheels, slow traverse speeds of work, running the wheel too far over the ends of the work, grinding long work without backresting, setting the reverse dogs for each individual piece, and neglecting to use the automatic cross-feed. These are by no means all of the reasons for curtailed production. However, they are the most important to be considered at present, and for the sake of convenience they will be taken up one at a time.

The average shop foreman who served his time long before the introduction of modern grinding methods, has had no practical experience concerning them. For this reason he is satisfied with results that otherwise would be more closely investigated. The makers of grinding machines and grinding wheels are at the present time getting excellent results and high efficiency with their products, and there is no good reason why the average shop foreman cannot get the same results, if local conditions will permit.

As mentioned, the average grinding machine operator seems

* For additional information on this and kindred subjects, see the following articles previously published in MACHINERY: "The Field for Grinding—A Comment," July, 1911; "Rough Turning vs. Rough Grinding of Crankshaft Pins," March, 1911; "The Field for Grinding," January, 1911; "Precision Grinding," January, 1911; "Grinding Economy," July, 1910; "Grits and Grinding Chips," June, 1910, engineering edition; "Economy in Grinding," May, 1910; "Cylindrical Grinding," May, 1909; "Helps and Don'ts for Grinding," August, 1908; "Grinding and Grinding Machines," April, 1908; "Precision Grinding," September, 1907, engineering edition.

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to have the idea that because he is employed on accurate work, he should be a long time in doing it, feeling his way along carefully, and at the end obtaining the finish by the slow and out-of-date method of letting the wheel "grind out." In justice to the thousands of operators employed on grinding machines, it should be stated that the amount of time "killed" on the grinding job by "soldiering" is insignificant when compared to the time wasted through lack of knowledge concerning modern methods. In nine cases out of ten, the grinding machine operator did not have a competent man to "break him in" on the job. He had to work out his own salvation. It was a case of making good or getting fired. Therefore, he is not wholly to blame if he chose what seemed to be the easiest way of doing his work accurately. Another mistake, and one which is quite common in some localities, is to have the operator run two cylindrical grinding machines at once. The result is that one of the machines is running on a "blind" feed about half of the time. This may look all right, but it must be remembered that overhead expenses are going on while production is at a standstill. The practice recommended by the most successful makers of grinding machines, is that one operator should run but one machine at a time, in order that the machine may produce the maximum of work.

It seems to be a common error in the majority of shops to have a large variety of grinding wheels for one machine, whereas a few would be sufficient. For the ordinary plain grinding machine four, at the most, are enough, *viz.*: one for cast iron, one for very low carbon (cold-rolled) steel, one for 30-point and up carbon and crucible steel, and one for hardened steel. For the universal grinding machine, which is generally used for finishing tool work such as jig bushings, reamers, cutters, etc., one wheel will often suffice, provided it is of the proper material, and of the right grit and grade.

Wheels of too fine grit are another source of curtailed production. Many operators are of the opinion that a fine grit is necessary for producing a fine finish. This is an erroneous idea. A mediumly coarse wheel, provided it is of the proper grit combination, will produce as good a finish as a fine wheel of a straight grit, if used under the proper conditions. Wheels finer than 60 in a straight grit are practically useless for the majority of precision grinding operations. They cut slowly, call for a fine traverse feed, heat the work, glaze, and are the source of various other troubles.

The average grinding machine operator knows but little concerning the selection of wheels for various classes of work, the shop foreman less, and the purchasing agent, who generally selects the wheels, still less. For this reason, the majority of the progressive concerns leave the selection of wheels to the maker, describing the work, the kind of material to be ground, and the finish desired. It must be remembered that the makers of grinding wheels have a wider experience than any one operator or concern can ever hope to get, and for this reason are more competent to select wheels, provided the proper data are submitted to them. To be sure, they make mistakes once in a while, but before condemning a wheel as useless for a certain class of work, the operator should make sure that it is run at the proper speed. A good rule, followed by many, is to speed up the wheel if it wears out too readily, and to reduce the speed if it glazes. Many operators condemn wheels that would show high efficiency if run at the proper speed. They seem to be under the impression that the wheel should show the highest efficiency under any and all conditions.

Some ten or fifteen years ago—in the days of the fine-grit and hard-grade wheels—it was necessary to use a fine traverse feed to overcome the tendency of the work to chatter. For the same reason three-quarters of the face of the wheel was often cut away with the diamond. This practice, which in many shops has been handed down to the present time, is a fruitful source of curtailed production. The modern grinding wheel with its wide face and open bond is very free-cutting, and for this reason the traverse feed can be greatly increased. In roughing, the traverse feed should be very nearly the width of the wheel for each turn of the work. In other words, if the wheel has a one-inch face, the work should move past the wheel about seven-eighths inch for each turn. For the finishing cuts, the feed can be much finer, depending on the quality of the finish desired. If a fast traverse feed causes the work to chatter, this should be overcome by proper back-resting.

Many operators waste much time in permitting the wheel to feed way past the end of the work before reversing. This is especially true in grinding work like bushings, where the wheel can run off both ends of the work. The reason for this is the belief that the wheel, if dwelling in one spot during the reversal, will wear this place under size. Modern practice has proved this belief to be wholly erroneous; the outside edge of the wheel should pass the end of the work about one-eighth inch, but no more.

Long or slender parts should always be backrested when it is desired to turn out accurate work free from chatter marks. The improved rests supplied with grinding machines, possessing the advantages of both the solid and spring rest, can be used to advantage on the majority of cylindrical work. A good rule for spacing the rests is to place one for every foot of work of about one inch in diameter. Larger work does not call for such a close spacing of the rests. In placing rests, the following method is often employed with good results: Suppose the operator has a shaft to grind four feet long and one inch in diameter. First grind a spot and locate a rest one foot from the footstock. In grinding this spot, feed the wheel directly into the work, bringing the diameter to within 0.002 inch of the finished size. Next, locate a rest one foot from the headstock in the same manner, and then one in the center. While taking the roughing cuts the rests should be used "solid," that is, with the jaws fastened. For the finishing cuts the springs can be used to keep the jaws against the work, care being taken to see that they do not bear hard enough on the work to throw it out of alignment.

Another common error that causes waste of time is the setting of the reverse dogs for each individual piece to be ground, when the operator has several pieces of the same length to grind at a time, and when the wheel has to be fed quite close to a shoulder. If the pieces were all centered alike this individual setting would, of course, be unnecessary. However, as they never are centered alike, care has to be exercised as otherwise the wheel will be likely sometimes to gouge the shoulder of the work. A safe and efficient way is to proceed as follows: First bring the wheel to within 1/32 inch of the shoulder and feed directly into the work, bringing the diameter to within, say, 0.002 inch of the finished size. Then proceed to grind in the usual way, setting the reverse dog to reverse the wheel when within ¼ inch of the shoulder. This will answer for all the pieces and will take care of the irregularities due to errors in centering. When the work is ground to the desired size, feed the wheel by hand over the small portion near the shoulder not yet ground.

For the majority of cases of cylindrical grinding, the automatic cross-feed should be used. The knock-off should, of course, be adjusted, as otherwise the piece will be ground undersize. The cut should be as deep as the wheel and machine will permit, without unduly heating the work. When a number of pieces are to be ground it is good practice to first rough-grind all of them, bringing the diameter to within 0.002 inch of the finished size, and keeping the wheel sharp and free-cutting meanwhile. The wheel should then be trued off, using for this purpose a diamond which is fed past the wheel with a slow feed. This gives the wheel the proper cutting edge to produce a nice finish without any waste of time. Many operators rough and finish pieces one at a time. This is very poor practice, and should be discouraged, as it is not only a waste of time, but shows a lack of knowledge of the first principles of commercial grinding. Working under these conditions, the wheel has not the proper cutting face for either operation.

In conclusion, it can safely be stated that no one person "knows it all" when it comes to cylindrical grinding. The field is large, and in a few years practical results will be attained along these lines that are hardly dreamed of at the present time. The grinding machine operator should endeavor to gain all the knowledge he can concerning his work, by study and observation, ever bearing in mind the fact that the man who knows "how" does not have to depend on a labor organization to secure the maximum wages paid in his locality.

THE MANUFACTURE OF STEEL BALLS*

ROUGH GRINDING, HARDENING, AND FINISH GRINDING

By ROBERT H. GRANT†

In the article on ball making in the February number of MACHINERY, the methods of making the blanks and preparing them for the dry grinding were explained. In the present article the grinding and hardening operations will be dealt with. The old English method of grinding the balls was mentioned in the previous article, the balls being ground between two circular plates, the upper one of which was revolved by hand. The increased demand for balls in the bicycle industry soon brought about improved methods for grinding, the first step being to fasten the top plate to the spindle of a drill press, while the bottom plate rested on the table of the machine. In this way work was produced very much faster but no better quality was obtained than formerly.

Fig. 1. Battery of Early Type of Ball Grinding Machines

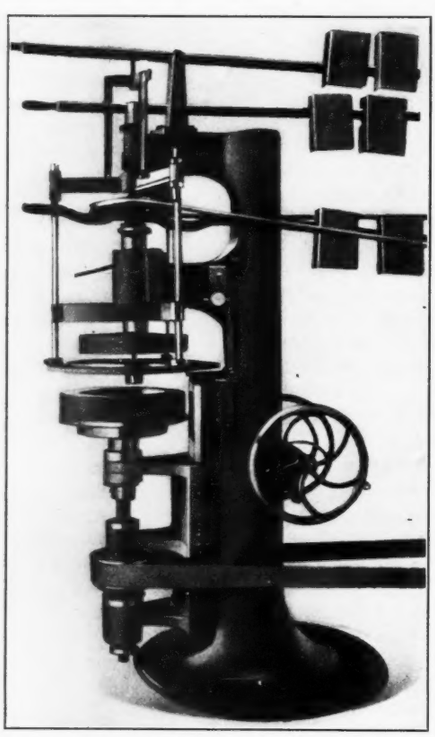

Fig. 2. Richardson's Ball Grinder

About the time when the first steel balls were manufactured in this country, special grinding heads of a much more substantial character were devised. Fig. 1 shows a row of oil grinders, such as were first made in this country. The head is made in the form of a goose neck, and has three bearings. The lower, or main, bearing has a quill the same as a drill press, with a rack cut in it. A lever with pinion teeth cut on the end meshes with this rack and provides the means for raising and lowering the head. The spindle, which has a large faceplate fastened to the lower end, carries the upper grinding ring, which is fastened to the faceplate by three screws. The main drive is through a set of bevel gears on the countershaft directly over the spindle of the machine. A vertical shaft transmits the power from the countershaft to the spindle. As all the blanks at this time were either pressed or forged, instead of being turned, the amount of stock to be removed was considerably more than it is when turned ball blanks are used. For this reason the time required for grinding ¼-inch balls was from one-half to three-quarters of an hour, and if the rings were badly worn the balls would come out of the grinder considerably out of true. It was, therefore, necessary to devise a better and quicker process—a rough grinder—for removing the surface of the balls. It is especially necessary to remove the surface to some depth when the balls are forged, as the outside is then apt to be decarbonized.

The Richardson Rough Grinder

The first rough grinder for balls, as far as the writer knows, was made by Mr. Henry Richardson, president of the Waltham Emery Wheel Co., Waltham, Mass., in 1877. Mr. Richardson, in speaking of this machine, has mentioned a few interesting facts about his experiments along this line. He took a regular 16-inch bastard file and ground a 90-degree groove in the center, almost the entire length of the file. The groove was ground clear through the file so that it would allow a 5/16-inch ball to project through to such an extent that the ball could be ground by a wheel without the latter touching the file. An emery wheel was then fastened to the faceplate of a lathe, and the file was clamped to the carriage in a vertical position. A plate with an elongated slot, which could be moved up and down on the tailstock spindle, was then made. The file with the balls was now placed against the emery wheel, and the plate on the tailstock was placed against the balls. The lathe was then started. The balls at once began to move in the V-groove in the file, and by moving the plate on the tailstock spindle up and down, the balls were turned in all directions, producing in a very short time a blank which was a comparatively true sphere.

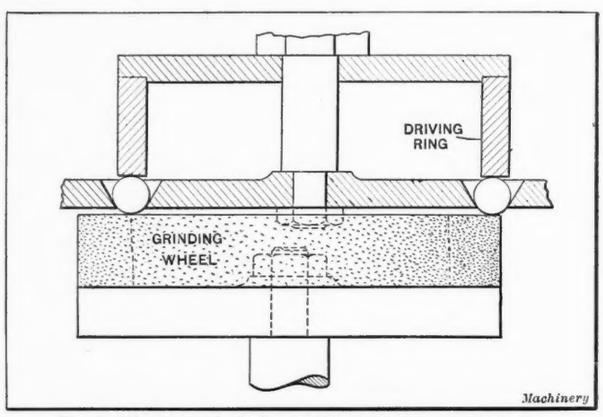

Fig. 3. Diagrammatical View of Principal Arrangement in the Richardson Ball Grinder

Mr. Richardson then made a trial machine which worked very satisfactorily, but as a photograph of this machine was never made, no record of its appearance is preserved. In 1878 he went to England and sold the English patents to Mr. Wm. Bown. A sample machine, as shown in Fig. 2, was made at this time. The patent held by Mr. Richardson did not, however, properly cover the invention, so that he was unable to get full returns for his efforts. The only claim of any im-

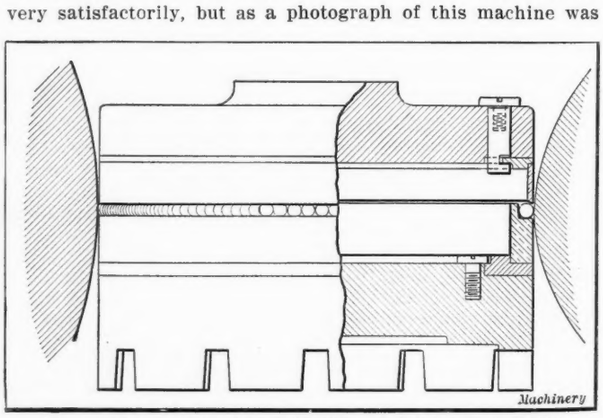

Fig. 4. Principle of the John J. Grant Rough Grinder—U. S. Patent No. 535,794

* See MACHINERY, February, 1912: "The Manufacture of Steel Balls—Making the Blanks."

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State University of Iowa 11 MAI 1912

portance which he held was as follows: a ring of balls in a V-groove, revolved by a driving ring and exposed to an emery wheel. This claim was the direct result of his experiments, and by itself was very far-reaching. It gave the ball makers, who soon began to spring up all over the country, a great deal of trouble in their efforts to "go around" it.

As shown in Fig. 2, the emery wheel is placed on the lower spindle which is mounted in the movable head; this head is operated by the handwheels at the rear of the machine. The emery wheel is eccentric with the top ring, so that the whole surface of the wheel will successively come in contact with the balls. This keeps the wheel in perfect shape. The V-groove in which the balls rest is formed by two annular rings or plates (see diagrammatical view in Fig. 3); the outer one is held and adjusted by three long bolts (shown in Fig. 2), while the inner plate is fastened to a rod which passes through the drive shaft to the top of the machine. This inner plate is operated by the middle lever shown, so that the balls thus can be "dropped" when finished. The driving ring which revolves the balls is adjustable in an up and down direction by means of the lower lever, and is clamped in the proper position by the small lever on the main bearing. This driving ring runs in the opposite direction to the emery wheel; the latter is run at a peripheral speed of approximately 5000 feet a minute.

On account of the fact that the outside of the balls run faster than the inside, as they are driven around by the drive ring, the balls assume a spiral motion, thereby exposing all sides to the emery wheel. An approximately accurate sphere is thus produced.

The John J. Grant Rough Grinder

In 1888 when the Simonds Rolling Machine Co., of Fitchburg, Mass., was grinding balls by the old English method, it could only produce balls which were true within 0.003 inch. This accuracy was considered sufficient at that time. Mr. John J. Grant, who was at that time employed by this company, and who had improved the Simonds rolling machine, proceeded to devise a machine which made it possible to produce balls far superior to any ever made. The principle of his first machine, which was a rough grinder, is shown in Fig. 4. This machine produced excellent work, but was very slow in its operation, as the balls had to travel one-half of the circumference of the groove in the ring without coming in contact with the emery wheel. On balls of smaller sizes, the upper or driving ring was so thin that it was possible to grind but a few balls before the emery wheel would wear it away. As shown in Fig. 4, the balls were held at the periphery of the stationary ring in a V-groove. The drive ring was extended over the balls far enough to drive them, and was driven by a pulley on the spindle which held the drive ring. The speed was not over 60 revolutions per minute. A saddle, which was stationary on the base of the machine, carried the emery wheel heads, each head having two wheels, so that the surface coming in contact with the ball would be as wide as possible. The driving pulley was placed between the emery wheels, all being driven from the same countershaft. The upper or drive ring could be raised by a lever at the top of the machine, and the lower ring could be revolved by throwing out a latch with a foot lever. This allowed the machine to be loaded and unloaded very rapidly. Notwithstanding the fact that this machine was very slow, as compared with the Richardson machine in which the emery wheel was on the balls at all times, it was successful, and it was possible for the Simonds company to produce a ball better than those produced by any other manufacturers, and the company, therefore, soon controlled the ball trade.

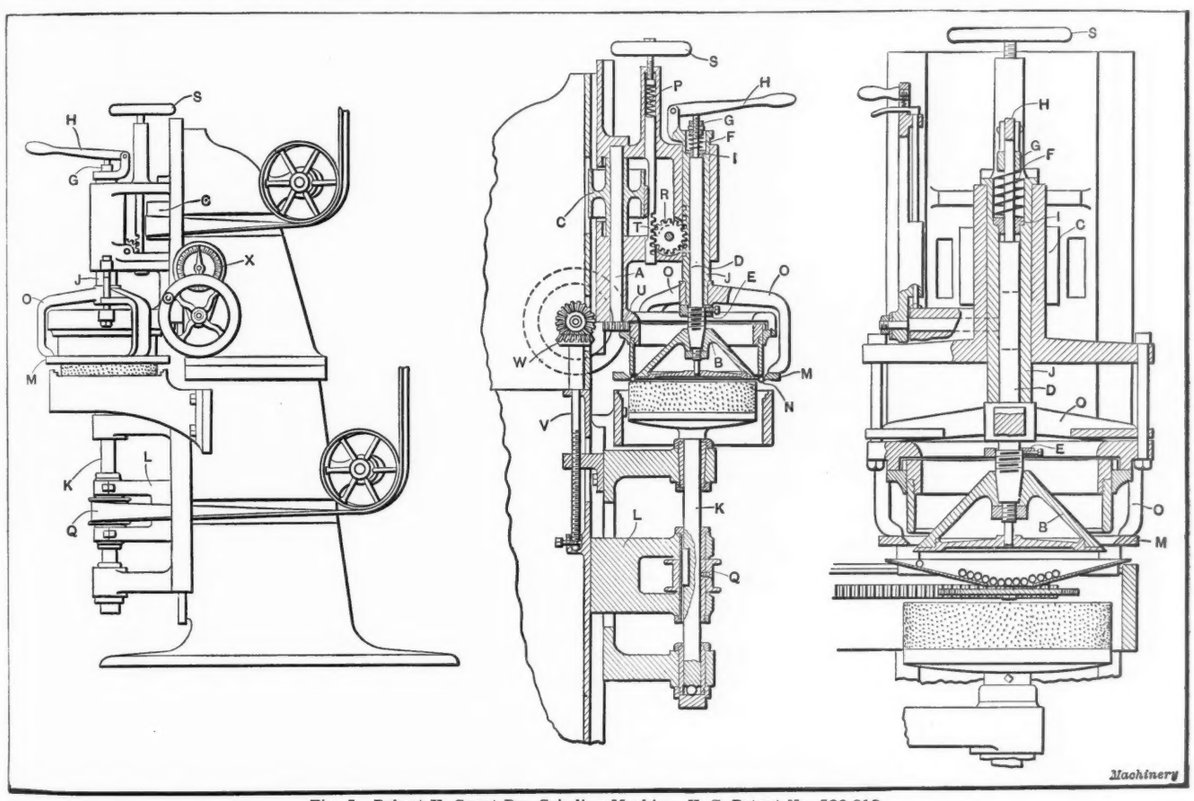

Fig. 5. Robert H. Grant Dry Grinding Machine—U. S. Patent No. 520,019

In 1891, the Grant Anti-Friction Ball Co. was formed by Mr. J. J. Grant, and a great many experiments in the dry grinding of balls without the V-path and drive ring were undertaken, but the experiments were not successful. It was, therefore, necessary to buy Mr. Richardson's patent, and around this was built the most successful dry grinder ever produced.

The Robert H. Grant Dry Grinder

In Fig. 5 are shown general and sectional views of the grinding machine designed by the writer, as originally made. It will be seen that the Richardson path is used in a modified form. The drive ring is driven through a gear on the drive ring holder, this gear, in turn, being driven by pinion *U* which is fastened to the shaft *A*. This shaft carries pulley *C* at its upper end. The cone *B* has a plate with hardened segments screwed to its lower end which form the inner part of the race *N*. The cone is fastened to the shaft *D* which is adjustable by collar *E*. On the upper end of the shaft is a spring *F* which is compressed between the collar *I* and the adjustable sleeve *G*. By means of the lever *H*, the shaft *D* can be lowered, thereby allowing the balls to drop into a receptacle after being ground, as shown in the view to the right. On the

rear of the quill *J*, which carries the shaft *D*, is cut a rack in which pinion *R* works. The shaft *T* which operates pinion *R* is adjusted by the spring *P*, controlled by the handwheel *S*. On the lower part of the quill *J* is fastened the spider *O* which carries the ring *M*, to which are screwed the hardened segments forming the outer path.

It will be seen that when the rough forgings are placed in the V-path, the driving ring is stationary, but the inner ring can vibrate on account of the action of the spring *F*. The outer ring *M* is permitted to vibrate slightly through the means of the spider *O*, quill *J*, pinion *R* and spring *P*. In this way the rough forgings will be ground only on the high spots until the balls become round.

The loading and unloading is done without stopping. When the balls are finished, the emery wheel is lowered and a pan is pushed under the path of the balls. The handle *H* is pulled down, thus allowing the balls to fall into the pan. The spider *O* is then lowered by means of the lever on the end of the shaft carrying pinion *R*. This allows the balls to be ground to be fed into the path *N*, and permits the grinding to commence without interruption.

The emery wheel, which is eccentric with the path of the balls, so as to allow the balls to successively cover the whole surface of the wheel, is carried by the lower head. The spindle *K* carries the pulley *Q* which is driven by a belt running over idlers to the countershaft above. Head *L* is raised and lowered by the screw *V* and the bevel gears *W*. The indicator *X*, having a pointer as shown, is connected to this mechanism, and shows the operator how many thousandths inch more he must remove from the balls. With the introduction of this machine the cost of making balls was cut in two, and the quality obtained was far superior to anything which had so far been produced.

The Hawthorne Method of Rough Grinding

About the time when the writer had designed the machine just described, the Hawthorne Mfg. Co., of Bangor, Me., decided to enter into the manufacture of steel balls. This company originally manufactured boot calks and other lumbermen's supplies. Some articles were manufactured for this concern by the Simonds Rolling Machine Co., and representatives of the company frequently visited the Simonds plant. They observed the great number of balls that were beginning to be used in this country, and hence concluded to enter into this field. The first grinder employed by this company made use of sand instead of emery. A bed of sand had been found in which the grit was so hard that it would cut the surface of a ball and last for a considerable length of time before being pulverized. The grinding was done in a closed path in which water and sand were used freely. The sand was fed from bins overhead, and washed out by water when pulverized. This was a very cheap process, as far as the grinding material was concerned, but did not produce a perfectly spherical blank. The oil or finishing grinders had to be relied upon to round up the balls, and a great many seconds and thirds were produced. The process was applicable, however, to the small balls mostly used at that time, nearly all balls being employed in bicycles. For larger balls, such as are now used in automobiles and other machines of the present day, these machines would have been useless.

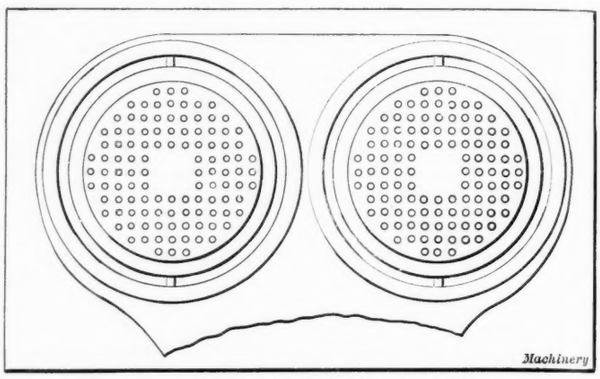

Fig. 8. Arrangement of Balls in the Putnam Grinder

The Putnam Ball Grinding Machine

About 1899, Mr. H. M. Putnam, who for several years was connected with the Simonds Rolling Machine Co., started the Fitchburg Steel Ball Co., and invented a dry grinder, as shown in Figs. 6, 7 and 8. This machine, which had to be constructed without the Richardson path, was made in the following manner: The lower plate *A* which corresponds to the drive ring, was driven through the tube *B* which carries the pulley *C*. The plate *D* which is countersunk as indicated at *E*, Fig. 7, (see also Fig. 8) is made from saw steel and hardened; it is then forced onto spindle *F* which carries pulley *G*. The cylinder *H* is adjustable by means of the screw thread *K*, and can thus, by means of handwheel *O*, be raised or lowered by the operator so that the balls will come in contact with the emery wheel *L*. This wheel is fastened to the upper spindle *N*, which

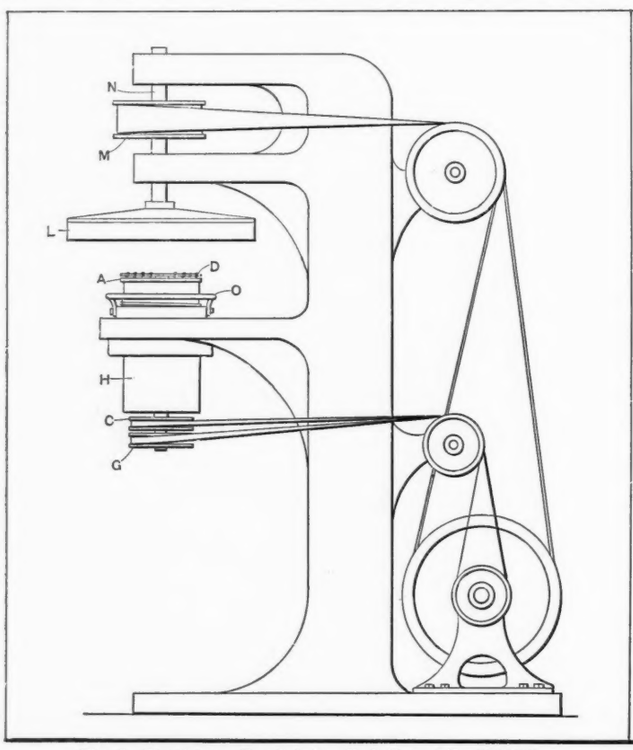

Fig. 6. The Putnam Dry Grinder—U. S. Patent No. 664,823

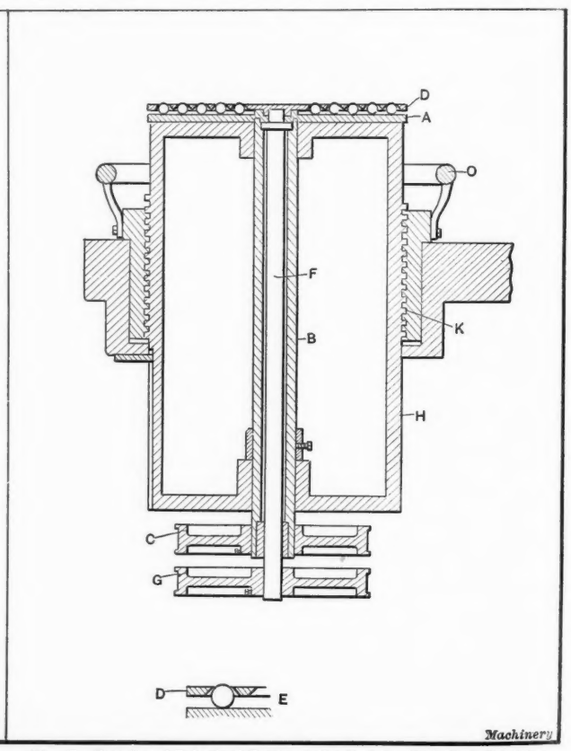

Fig. 7. Details of Principal Parts of the Putnam Grinding Machine

is driven from pulley *M* by a belt passing over two idler pulleys to the countershaft on the floor, as shown. This machine is very simple, but it does not grind an accurate ball on account of the balls being at various distances from the center, thereby giving them different rates of speed. The outer balls are ground faster than those at the center, and thus balls of all kinds of diameters and degrees of accuracy are produced. The balls are not held firmly in the path as in the Richardson grinder, but are simply confined in the countersunk holes so that they will not be thrown from the plate. This allows the ball to take its own course, and it becomes badly out of round

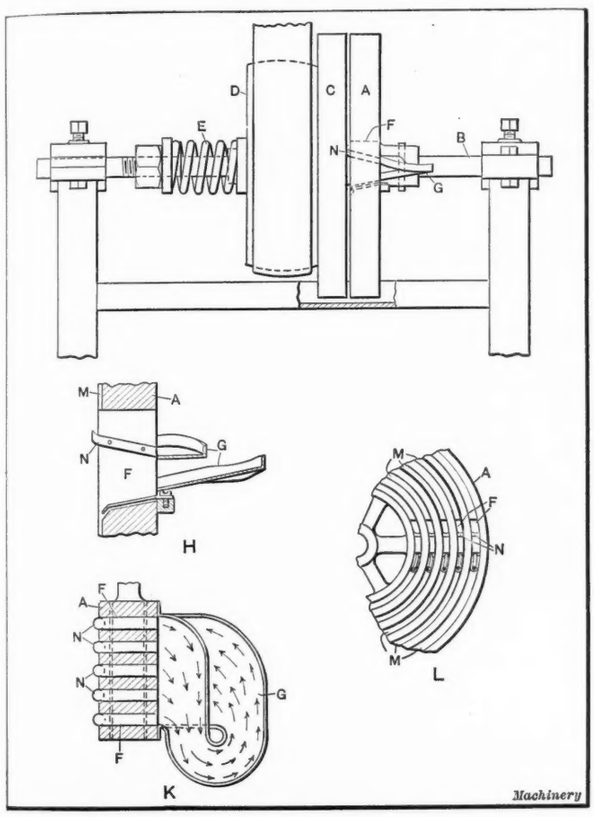

Fig. 9. The Hoffmann Ball Grinding Machine—U. S. Patent No. 803,164

during the grinding process. The writer is of the opinion that this machine might have been improved, but the company discontinued business soon after the machine was built.

The Chicago Steel Ball Co.'s Grinder

About the same time the Chicago Steel Ball Co., of Chicago, Ill., brought out a dry grinder which had several good features, and which was somewhat similar in operation to the well-known Hoffmann machine which will be described in detail in the following. The Chicago Steel Ball Co.'s machine had the emery wheel and the drive wheel placed in a vertical position. There were several concentric circular paths on the drive ring, and the balls were transferred from one into another, thus giving the balls a different spiral motion on account of being at various distances from the center. This machine ground a very accurate ball, but on account of its poor construction and the poor method used for transferring the balls from one path to another, it was but little used, and, therefore, had no particular influence on ball manufacturing methods.

The Hoffmann Grinder

What may be considered as one of the best ball grinding machines constructed was invented in 1905 by Mr. E. G. Hoffmann, who was at that time connected with the Hoffmann Ball Co., in England. This machine required several years for its development, but when completed it produced a very accurate ball, and is greatly appreciated by ball manufacturers.

In the article on ball manufacture published in the February number of MACHINERY, the Hoffmann ball turning machine was described. The blanks produced by this machine are accurate, and but little grinding is required on them. These balls, therefore, are especially suited for grinding in the Hoffmann grinder, as this machine is very slow, and cannot be used to advantage on pressed blanks or forgings, unless they have been previously rough ground by some other process. The machine is automatic, and requires little or no attention, except for gaging the balls at intervals during the grinding. The machine requires from three to five hours for removing 0.001 inch on a ½-inch ball.

In Fig. 9, diagrammatical illustrations of the Hoffmann machine as originally designed, are shown. Pulley *D* is driven by a belt from the countershaft, and revolves upon a stationary shaft *B*. The pulley is fastened to the disk *C* which has a series of grooves in its face. Plate *A*, which also has a series of concentric grooves to correspond with those on disk *C*, is stationary and is fastened to shaft *B*. The balls are placed in the machine so as to fill all the concentric grooves, spring *E* forcing disk *C* against plate *A*, thus holding the balls in place. The machine is then started, and the balls, by means of the mixer and interchanger shown in two views at *H* and *K*, are changed from one groove to another.

As indicated at *H*, *K* and *L*, slots *F* are cut through the stationary disk, a slot being directly opposite each of the grooves *M*. In each slot is placed a finger *N* which projects slightly beyond the bottom of the groove into the corresponding groove in the rotating disk *C*. The function of the finger is to stand in the path of the balls so as to positively dislodge each ball from the groove as it reaches the point where the finger is located. Each finger discharges the ball from the corresponding groove upon a table *G* which affords a surface upon which the balls may roll, and which also directs the balls back toward the grooves below the fingers, the table being slightly inclined toward the lower portion of the slots *F*. It will be seen that this keeps the balls moving from one groove to another so as to place them at

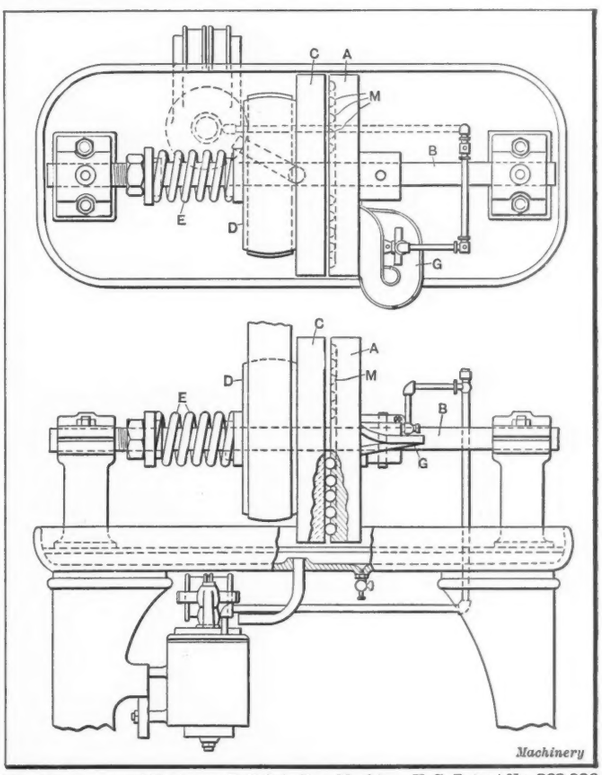

Fig. 10. Improved Hoffmann Ball Grinding Machine—U. S. Patent No. 868,926

different distances from the center at each revolution of plate *A*. This results in the grinding of a very accurate ball.

The grinding is done with oil and emery introduced in the required quantities upon the table *G*, and fed into the machine by the balls. This machine was further improved by the introduction of an emery wheel in place of the grinding ring *C*. The improvement was very marked, as the grinder *C*, when made of cast iron, was apt to be spongy, and softer in some spots than in others; it would, therefore, quickly wear out of shape. The replacing of this disk by the emery wheel overcame these difficulties. Kerosene oil is used to keep the grooves clear of the loose particles of abrasive material, and

prevents the balls from being badly scratched or cut. A very peculiar fact about this grinder is that the emery wheel is run at only 75 revolutions per minute, instead of at the peripheral speed of 5000 feet, generally required by emery wheel manufacturers.

Annealing and Hardening

After the balls have been rough ground so as to remove all scale and decarbonized surface resulting from the forging operation, they are taken to the hardening room where they are first annealed. This annealing removes any internal stresses caused by forging or other methods of blanking. The

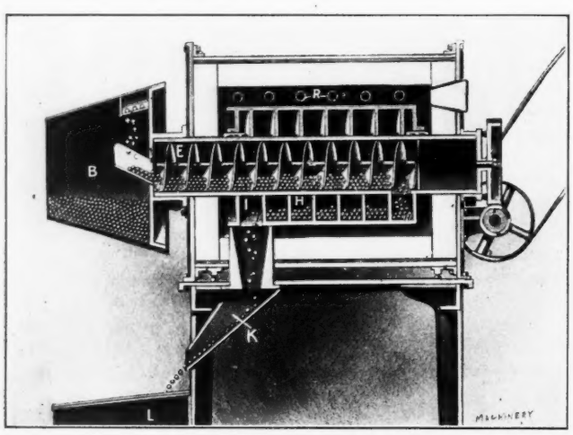

Fig. 11. Section of Ball Heating Furnace, made by the American Gas Furnace Co.

process, as indicated in Fig. 11, is automatic. The balls are fed into the hopper *B* which is revolved by a worm and worm-wheel placed at the opposite end of the machine. From this hopper the balls are fed into the spiral *E* which they follow until they reach the opposite end, where they drop into the outer spiral *H*, which is revolved in the opposite direction. Finally the balls fall out of the cylinder at *I* into the funnel *K*. The machine is heated by gas with burners at *R*, thus preventing the heat from coming into direct contact with the balls and decarbonizing the surface.

After being annealed, the balls are put through the same machine to be heated for the hardening. They are heated to exactly 1275 degrees F., the temperature being determined

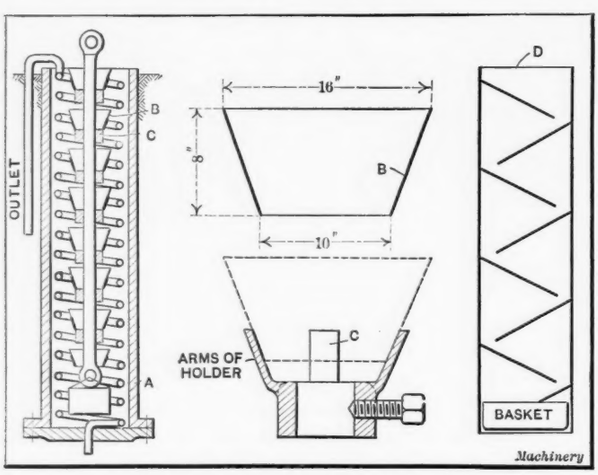

Fig. 12. Tanks used for Quenching Balls

by a pyrometer. The thermo-couple is placed near the point where the balls leave the cylinder.

The smaller balls are dropped into a reservoir of oil, while the larger ones are immersed in brine. The oil reservoir, shown at *A* in Fig. 12, consists of a length of 30-inch water pipe, one end being provided with a head strongly bolted to it so that it is water-tight. The pipe is sunk into the ground so that the top can receive the balls, as indicated at *L*, Fig. 11. Inside of this cast-iron pipe is placed a coil of 1¼ inch water pipe, in which cold water is circulated in order to keep the bath cool. A rod with a number of inverted galvanized iron cones *B*, adjustably fastened onto the rod by the holders *C*, is then placed in the bath. (Parts *B* and *C* are also shown in detail in Fig. 12.) When the balls drop into the bath in the pipe, they strike the side of the upper cone, which shoots them off at an angle until they strike the opposite side of the next cone; this reverses their direction of motion, so that they reach the basket at the bottom in a zigzag path, thoroughly cooled off. When the balls are thus cooled off, the rod with the basket at the lower end is pulled out, and the balls in the basket are allowed to drain, the oil draining back into the pipe.

The best oil for the hardening of balls is cotton-seed oil; while it is very expensive, it has sufficient body to cool the balls thoroughly, and it does not need to be replaced. It is only necessary to add to it, from time to time, due to the loss from evaporation.

The larger balls are hardened in brine. The machine shown in Fig. 11 is placed at the edge of a tank of the type shown at *D*, Fig. 12. This tank has a series of shutters made in the form of steps overlapping each other as indicated. These steps force the balls to traverse in a zigzag path through the brine in the tank for a considerable time before dropping into the basket at the bottom.

Fig. 13. General View of the Grant Dry Grinding Machine, with Samples of Largest and Smallest Balls ground in it

The largest balls are heated for hardening by being placed on the tiling of a regular casehardening furnace, similar to that made by the Brown & Sharpe Mfg. Co., and are allowed to heat slowly through to the center, the balls being revolved gradually. Two or more balls, according to size, are then placed in a wire basket and rapidly swung to and fro in the brine tank until thoroughly cooled off. All balls, as soon as they are taken from the hardening tanks are placed in a kettle of boiling soda, not only for the purpose of washing them, but also to prevent the air from coming in contact with them at a time when they are extremely hard. The balls are then placed in the drawing kettles, which are filled with oil heated to 325 degrees F.

Finish Grinding

The balls are now ready to return to the finish dry grinding department, where the same machine as shown in Fig. 5 is used (except that a finer grade of emery wheel is employed) to reduce the balls to the proper size for the oil grinders. For this finish dry grinding the inner and outer segment are ground true, so that the path formed is a perfect track for the balls.

State University of Iowa 11 Jan 1912

In Fig. 13, the improved Grant machine (Fig. 5) is shown, with the two extremes in size of balls which this machine will grind. In Fig. 14 is shown the special grinding machine which is used for grinding the segments that form the path for the balls. These special grinders are very simple in construction, the wheel head being solid and the spindle on which the segment plate is fastened being driven by a worm through a shaft from a pulley in the rear. The two adjustments up and down and in and out are operated by the shafts which project in the front. By this grinding, the segments are made absolutely true, and by grinding the drive ring by the emery wheel on the machine on which it is used, the balls will make contact on three points absolutely true with each other, and hence the balls produced will be absolute spheres, ready for the final oil grinding.

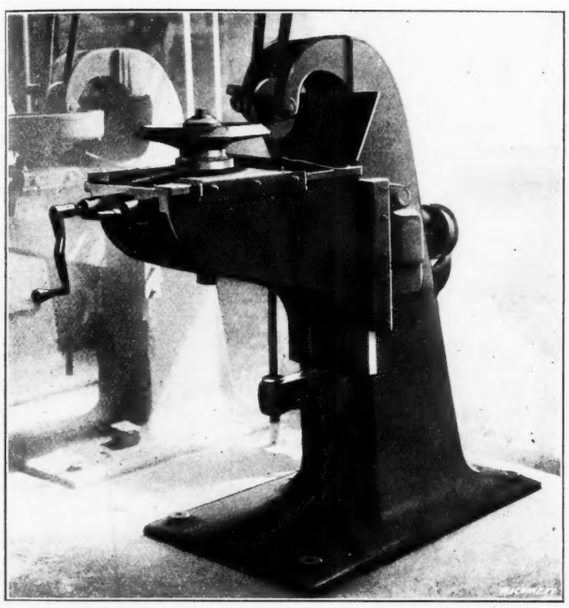

Fig. 14. Special Grinding Machine used for Grinding the Segments for the Path of the Balls in the Machine shown in Fig. 13

Fig. 17 shows the ordinary type of oil grinders. These are usually placed in groups of three. The machines are provided with a quill, on which a rack is cut for raising and lowering the head by means of the lever shown projecting at the front of the machine. The machines run about 450 revolutions per minute. The oil grinding constitutes the final finishing operation, and requires considerable skill. The operator must know just how much oil and emery to use, and how long to run the rings so as to make the balls round up.

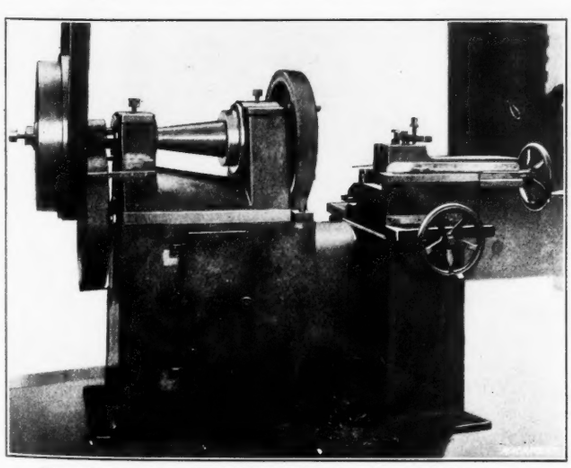

Fig. 15. Ring Turning Lathe for Dressing the Oil Grinder Rings

Assume, for example, that a man is to finish grind balls ¼ inch in size. In Fig. 16 is shown a diagrammatical section of the grinding rings. The circular path of the balls is usually 16 inches in diameter. A half circular groove is cut in the bottom ring, as indicated, and a small channel is cut at the bottom of the groove to allow the oil and emery to reach the bottom of the ball. The top ring is simply a cylinder shrunk onto a plate. This plate can be used over and over again, by merely breaking off the cylinder when used up and shrinking a new ring in place. The upper cylinder has a shallow groove in it for the balls. After the balls have been placed in the ring, the oil and emery are poured in, and the upper ring is lowered onto the balls, the machine then being ready to start. The ¼-inch balls should have 0.006 inch left for the finishing operation. The operator gages the balls and sets his clock on the head of the machine as many minutes ahead of the clock in the room as he knows will be required to obtain very nearly the final size. At this time he must stop the head and again measure the balls. The operator runs three heads, and as each head finishes its work at different intervals, he has ample time to stop any one head and take out three or four balls from different parts of the ring. After washing them in benzine, he measures them with his micrometer, testing both the size and roundness; if not to size, he replaces them and applies the required amount of oil, emery and speed, until he obtains a ball that is as nearly perfect as possible in all respects.

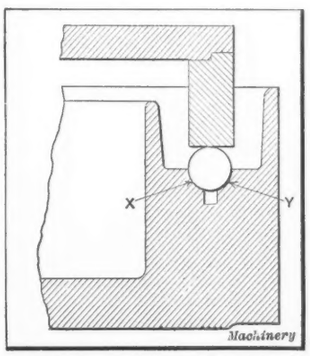

Fig. 16. Illustration of Principle of Action of Oil Grinders

The grinding ring should be of porous medium soft cast iron, as the oil grinding is merely a lapping process, and the ring must wear away to allow the balls to round up. On account of the larger diameter at the outside Y than at the inside X of the balls, Fig. 16, there is a greater peripheral speed at the outside. This causes the balls to move in a spiral path as they revolve, so as to bring all points of the surface in contact with the ring. The operator, when using a new ring for the first time, must make allowance for the ring not having become penetrated with emery, and also for its being cold. Later the output can be greatly increased. The heads on the grinders must be kept in perfect alignment, so that the balls will be ground on the entire circumference of the rings.

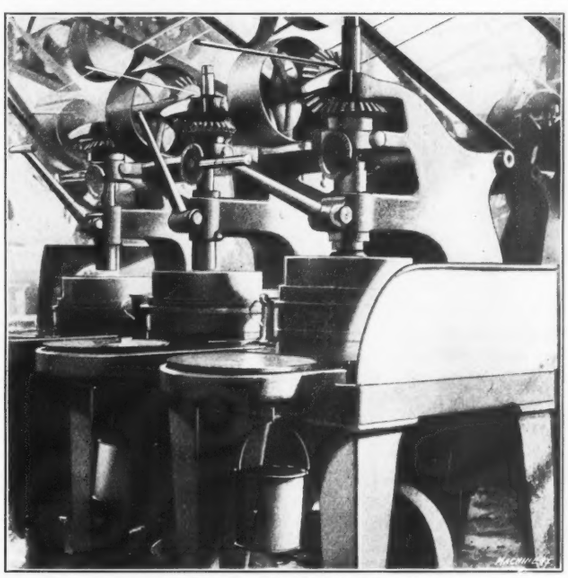

Fig. 17. The Oil Grinders

Fig. 15 shows a special ring turning lathe for dressing the oil grinder rings. It is necessary that these rings be free from chatter marks and imperfections of any kind, so that even the first sets of balls ground by them will be perfect; otherwise the first balls would have to be classified as seconds or thirds on account of poor grinding.

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MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition, $1.00 a year, which comprises approximately 700 reading pages. The Engineering Edition—$2.00 a year, coated paper, $2.50—contains all the matter in the Shop Edition, about 300 pages a year of additional matter and forty-eight 6 x 9 Data Sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. The Railway Edition, $2.00 a year, is a special edition including a variety of matter for railway shop work—same size as Engineering and same number of Data Sheets.

SHOULD ENGINEERING SOCIETIES PAY FOR CONTRIBUTIONS?

The papers read before American engineering societies are of two main classes. One class describes installations of machinery and apparatus, and the considerations that had to be taken into account by the engineers in charge. These papers are generally valuable and unobjectionable, notwithstanding their advertising nature. The advertising that the concerns and engineers get from the presentation of papers is the incentive that causes them to be prepared. The other class comes from college professors, and chiefly describes tests conducted by students for their theses. The professor advertises himself and his college with little effort by giving the results of his students' investigations in a paper. These papers are legitimate and commendable when the investigations have led to results of practical value. Both classes of papers are contributed at little or no cost to the authors and mean little or no personal sacrifice.

A third class of contributions, of which there are entirely too few examples, comes from men who give their personal time and energy to the subjects of their papers. They give freely to the engineering world that which has cost them much thought and time to reduce to a form that can be generally understood and appreciated. Great credit is due them for their generosity and enterprise. But, is the brief recognition accorded these able men adequate compensation? Is not the American Society of Mechanical Engineers losing many valuable contributions that would be offered by individuals if they could afford to give the time and labor to their preparation? How can the difficulty be met except by offering compensation for the results of investigation made by men who cannot afford to give their work freely?

The society's sub-committee on machine shop practice is required to present those details of practice that can be collected and described only by the men in daily contact with the conditions of manufacturing. These men are generally paid wages much lower than the salaries of engineers, yet we ask them to contribute their time and energy for the benefit of the mechanical engineering world. Their reward is the honor of having their papers read before the society, which is probably highly appreciated, but which may be of little actual value to the individual. Will the ethics of engineering societies prevent doing what seems necessary to secure the records of the most advanced practice?

* * *

HARDENING VS. TEMPERING

A contributor to MACHINERY has written a letter in reference to the tool tempering furnace described in October, 1911, taking exception to calling it a tempering furnace when it is clearly a hardening furnace.

The exception is well taken. Every reader of MACHINERY who knows anything about hardening steel is well aware of the distinction between hardening and tempering. To harden a piece of carbon steel, we must heat it to a "cherry red," then quench it in a bath which is usually pure cold water. In the state produced by cooling in the bath the steel is too hard for use, being brittle and liable to chip or crack. The hardness is reduced by heating the piece to the temperature which experience has demonstrated to be sufficient to reduce the hardness to that consistent with the use of the tool.

Heat treatment of carbon steel almost invariably consists of two operations, first hardening and then "drawing" the hardness or tempering it to the required degree. The definition of "tempering" in the Standard Dictionary, edition of 1899 is: "To bring (a metal) to a certain degree of hardness by heat and suddenly cooling. In tempering steel, the metal is usually heated until it assumes a color, as yellow, brown, purple, or blue, and then plunged into water. The degree of heat (as shown by the color) at which the cooling takes place determines the degree of hardness."

This definition clearly shows a lack of understanding of the distinction between hardening and tempering, but in justice to the lexicographer it may be said that tempering is a term that is often loosely used to mean both hardening and tempering, that is, both operations necessary for the proper heat treatment of carbon steel, although it should not be so used by those who know and understand the true meaning of the term.

* * *

THE GROWTH OF THE MOTOR TRUCK INDUSTRY

The recent automobile shows held in New York City were startling revelations to many business men of the importance of the motor truck industry, from both the manufacturers' and users' standpoints. For several years it has been the fashion of editors, economists and others to deplore the fact that the inventive genius and manufacturing enterprise of the country apparently was almost exclusively concentrated on the improvement and construction of automobiles for pleasure. It seemed that the more useful and enduring business of commercial car building was practically neglected. While these strictures were in the main true, the developments of the past two or three years show that a substantial body of designers and builders was planning and making commercial vehicles that are satisfactorily meeting the exacting demands of business in large cities and towns.

Commercial trucks have arrived at the practical stage, and although they still have defects and undesirable complexities, the men capable of operating them are becoming available, and business concerns are using them. The expense of keeping horses in large cities grows greater every year. Stables must be located where rents are low, and this means in sections generally remote from business centers. The time lost in traveling between the stables and the warehouses is a serious item which becomes still more serious in Manhattan where stabling is available mostly in Brooklyn and Jersey City. Ferriage and bridge tolls are added costs of daily operation.

In times of weather stress, horses are subject to accidents and the ills incident to exposure. Loads must be reduced or teams doubled to move normal loads. The motor truck is subject to mechanical troubles, but its practically unlimited power, great capacity, speed and short overall length are advantages that will become more and more apparent as drivers become trained to operate trucks efficiently.

To secure greater efficiency of men and trucks, power loading and unloading facilities will be developed. These will not only accelerate the moving of freight, but will make the operation of power trucks more attractive to a desirable class of men. One of the existing difficulties is getting men competent to drive motor trucks who are willing and able to handle heavy boxes and parcels. Cranes that will lift a box from the sidewalk to the truck will make the loading quicker, easier and safer for men and merchandise.

It is interesting to reflect on the change that will inevitably develop in the personnel of truck drivers. As a class they are now known as ignorant, "horsey" and abusive men, more familiar with saloons than churches. When they become largely a class of men trained to efficiently control powerful road locomotives, the discipline of mind and body necessary to the understanding of machinery and its control must necessarily produce in them the characteristics of a more desirable class of citizens. A drunken driver of a power truck will be too dangerous to tolerate, and he must disappear.

* * *

STANDARDIZATION WORK OF THE S. A. E.

The work of standardizing the characteristics of automobile elements undertaken by the Society of Automobile Engineers is proceeding satisfactorily, notwithstanding the many difficulties that beset it. The general method followed is adjusting shapes, center distances, dimensions and capacities of accessories to common standards that will insure interchangeability, and thus make possible variations of the equipment without necessitating changes in the construction of the basic structure to accommodate them.

Standardization will enable the manufacturer and the user of automobiles to change from one make of motor car element to another at pleasure. Take for example the magneto. To secure interchangeability of magnetos, it is essential that the distance from the base to the shaft center of all magnetos shall be a standard dimension; also that the distance from the bolt holes to the end of the taper shaft, the taper of the shaft and the overall height, length and width, be common. Within these restrictions, each maker will be free to express his ideals of construction and design without interference. The advantages that should accrue from this standardization work, carried on as it is under the direction of representative automobile engineers, can hardly be overestimated.

The work of the committees also includes fixing the physical and chemical characteristics of aluminum and copper alloys, iron and steel, etc. Committees have been appointed on the following subjects: aluminum and copper alloys, ball and roller bearings, broaches, carbureters, frame sections, gear tooth shapes, iron and steel, leaf and coil springs, lock washers, miscellaneous parts, automobile nomenclature, seamless steel tubes, sheet metals, truck standards, wheel dimensions and fastenings for tires. The secretary of the society in alluding to the difficulties of the work says:

> The old-fashioned practice of wrapping a given process up in mystery, or surrounding it with a halo of secrecy still persists. Trade secrets still exist and petty jealousies still continue, and all of these prevent frankness and the accumulation of complete committee knowledge. It is not fair to ask that all trade secrets be laid before committees, nor is it necessary that trade secrets should be exposed in order to give sufficient knowledge to a committee to enable it to proceed intelligently. It is fair to ask that all personal feeling and all trade jealousy be laid aside for the benefit of all concerned. The work of our society in adopting standards has received hearty recommendation from many outside sources, and only a few comments to the effect that the society was attempting the impossible. It is probably a safe statement to make that even these unfavorable comments would not have been made had the writers of them been familiar with what the committee were really trying to do. The adverse critics have been universally those who have not come forward, attended the meetings or even read any of the material placed before them.

* * *

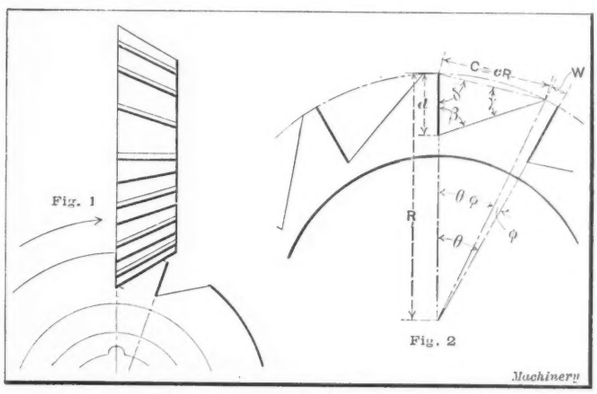
Practically all the vanadium used in the United States is obtained from Peru, South America. Extensive deposits of vanadium ore are located there and are controlled by American interests.

MILLING AXIAL TEETH IN CUTTER AND REAMER BLANKS*†

By GEORGE W. BURLEY‡

The ordinary method of setting the fluting cutter when milling axial teeth in cutter and reamer blanks, parallel to the axes of the blanks, is a cut-and-try method which, while it may give fairly good results in the hands of a skilled operator, is nevertheless rather wasteful of time and, in the majority of cases, indefinite in its results. The first part of the operation is to set the fluting cutter central with respect to the axis of the blank. In other words, where the fluting cutter is a single-angle cutter—as is usual for this class of work—it is arranged so that the vertical face is in the vertical plane passing through the axis of the blank, as is indicated in Fig. 1. The next step in the operation is to arrange the cutter so as to obtain the correct depth of flute. This is done by raising, in the first place, the knee, table, and blank an amount which, under any given circumstances, experience has indicated to be approximately correct.

With the blank in this position, two consecutive grooves are milled, the movement of the blank when indexing being in the direction represented by the arrow in Fig. 1. If the width of the land formed between the two grooves is about right, the position of the blank is assumed to be correct, and all the teeth are cut with the blank in this position. If the width of the land appears to be too great, the blank is further elevated so as to deepen the grooves, the amount of additional elevation being left entirely to the judgment of the operator. If the width of the land is too small, then the blank is lowered



Figs. 1 and 2. Diagrams illustrating Method of Finding Formula for Depth of Tooth Space

slightly to reduce the depth of the cut and increase the width of the land. This is obviously an inexact method and one not calculated to produce satisfactory results.

An exact method of determining the depth of the cut required for any given conditions in regard to the number of teeth to be cut in the blank, the diameter or radius of the blank, the angle of the fluting mill, and the width of the land to be formed, can, however, be adopted, the result of applying such a method always being satisfactory. The following is a consideration of the case. The conditions are shown in Fig. 2.

Let

* With Data Sheet Supplement.

† The following articles relating to the design and manufacture of milling cutters and reamers have previously been published in MACHINERY: "Setting Angles for Inserted-tooth High-speed Milling Cutters," December, 1911; "Face Milling Cutters for Finishing," December, 1911; "Milling Radial Teeth in Cutter Blanks," November and December, 1911, engineering edition; "Recutting Milling Cutters without Annealing," December, 1911; "Method of Setting Cutter for Fluting Spiral Mills," September, 1911; "Fluting Spiral Mills," August, 1911; "Fixture for Backing off Milling Cutters in the Lathe," June, 1911; "The Making of Reamers," July, August, and September, 1911 (see also the articles referred to in a note with the July installment); "Relief of Teeth of Cutters and Reamers," May, 1911; "Milling Cutters and Their Efficiency," May, 1911, engineering edition; "Reamers for Cutting Brass," April, 1911; "Spacing the Cutting Edges of Reamers," February, 1911; "Spacing of Cutting Edges of Reamers," November, 1910; "Apparatus for Hardening Milling Cutters," June, 1910; "Nicked Tooth Milling Cutters," April, 1910; "Milling Cutters with Inserted Teeth," December, 1909; "Length of Recess in the Bore of Milling Cutters," December, 1909, engineering edition; "Lathe Attachment for Backing off Teeth of Stepped Reamers," November, 1909; "Fixture for Grinding Radius Cutters," November, 1909; "Clearance on Milling Cutters," March, 1909. (See also the references to additional information given in a note with this last mentioned article.)

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N = the number of teeth (assumed to be equally spaced) to be cut in the blank.

W = the width of the land to be formed on each tooth.

β = the angle of the fluting or grooving cutter.

θ = the angle subtended at the center of the cutter or reamer by each tooth.

Then

$$\theta = 360 \div N$$

and may be called the tooth angle of the cutter or reamer. Let the radius of the finished (*i. e.* ground) cutter or reamer be R; θ is the angle subtended at the center of the cutter or reamer by the circular arc from which is formed the land of width W. This land may be either flat (as when formed by a cup-wheel) or concave (as when formed by a disk-wheel), but, in each case, the width of the land is measured in a straight line. The difference between the actual width of the land ground and the arc length (Fig. 2) is exceedingly small (though, other things being equal, it will depend upon the clearance), and, therefore, in this connection negligible. As the arc W subtends an angle ϕ at the center of the cutter or reamer, the angle $(\theta - \phi)$ is the angle subtended by a chord C. The angle $\delta = 90 - \dfrac{(\theta - \phi)}{2}$, and

$$\gamma = 180 - \left(90 - \frac{(\theta - \phi)}{2} + \beta\right) = 90 - \left(\beta - \frac{(\theta - \phi)}{2}\right)$$

The angle ϕ in degrees is obtained from $W \div R$, which is ϕ in circular measure. The chord C is, obviously, a function of radius R; hence its value is $c\,R$, where c is a constant for any particular values of θ and ϕ (from which it can be calculated) and, therefore, of N and $\dfrac{W}{R}$.

Let d = the depth of the cut required. Then, from Fig. 2,

$$\frac{d}{\sin\gamma} = \frac{c\,R}{\sin\beta},$$

from which we get

$$d = \frac{c\,R\sin\gamma}{\sin\beta} = \frac{c\,R\sin\left\{90 - \left(\beta - \dfrac{\theta - \phi}{2}\right)\right\}}{\sin\beta}$$

$$= \frac{c\,R\cos\left(\beta - \dfrac{\theta - \phi}{2}\right)}{\sin\beta} \qquad (1)$$

Recapitulation

It will be seen that by means of this formula, the depth of cut required for any given set of conditions can be calculated, the steps in the calculation being as follows: ϕ is obtained from $W \div R$ (the value of which is selected according to whether it is a milling cutter or a reamer which is to be fluted, and according to the kind of work which it has to perform. For medium-sized milling cutters, the quotient $W \div R$ varies from 0.020 to 0.060, while for reamers and small cutters its value lies between 0.040 and 0.120; θ is calculated from $360 \div N$; $c\,R$ is taken from a table of chords, it being the chord corresponding to $(\theta - \phi)$; and $\cos\left(\beta - \dfrac{\theta - \phi}{2}\right)$ and $\sin\beta$ are taken from the trigonometrical tables. Substituting the latter three values in Equation (1), we determine the depth of cut required.

It should be noted here that the very slight rounding which is usually given to the extreme angular point of the fluting cutter has been neglected in this consideration of the problem. This is because it is not possible to deal with it in a simple manner, and also because the amount of rounding is, in the majority of cases, not sufficient to affect materially the results of our calculations.

For practical purposes, the above formula is cumbersome, and, therefore, almost useless. To make it useful and of practical value, it has been converted into another formula, namely:

$$d = x\,R \qquad (2)$$

in which x is the depth of cut for a cutter or reamer of unit radius, and is equal to

$$\frac{c\cos\left(\beta - \dfrac{\theta - \phi}{2}\right)}{\sin\beta}$$

This is a constant for any given set of conditions, since, in such a case, W, N, and β, and, therefore, $W \div R$, θ, ϕ, and c will have fixed values. In the accompanying Data Sheet Supplement are given the values of x for a large number of different combinations of $W \div R$, N, and β; $W \div R$ ranging from 0.020 to 0.120 by increments of 0.020; N ranging from 6 to 44 by steps of 2; and β varying from 50 to 85 degrees.

Since the radius of the cutter or reamer blank is invariably made greater than the required radius of the finished cutter or reamer—the usual allowance on the diameter being about 0.008 inch per inch of diameter*—it is necessary to modify Formula (2) in order to fit it for application to conditions actually prevailing in practice. Obviously, in this case, to $x\,R$ must be added the difference between the radius of the blank and that of the finished cutter or reamer. Hence, the formula is:

$$d = x\,R + (R_1 - R) \qquad (3)$$

where R_1 = the radius of the blank. Another form is this:

$$d = R_1 - (1 - x)\,R \qquad (4)$$

Either of these two formulas may be used in practice, the value of x being taken from the accompanying tables in the Supplement.

To illustrate the use of this method, we will take the case of the fluting of a 5-inch cutter, which is to have 36 teeth, and a land-width ratio (*i. e.*, $W \div R$) of 0.020, the angle of the fluting cutter being 60 degrees. The blank, we will suppose, has been turned to a radius of 2.520 inches. Then, by consulting the accompanying tables, we find that $x = 0.1013$, and, therefore $x\,R = 0.2532$ inch; but $(R_1 - R) = 0.020$ inch; hence, $d = 0.2532 + 0.020 = 0.273$ inch, which is the required depth, and is an amount which can be easily read off the micrometer dial of the elevating screw of the milling machine.

It may sometimes be necessary to determine the value of x for a set of data not included in the accompanying tables. In such a case, this value can be calculated sufficiently accurately by the "simple proportion" method. To exemplify the use of the tables for this purpose, let us take the case of the fluting of a cutter involving the following data:

$N = 40$ teeth;

$\beta = 70$ degrees; and

$W \div R = 0.050$.

From the tables we find that when $W \div R = 0.040$, $x = 0.0494$, and when $W \div R = 0.060$, $x = 0.0402$. Therefore, when $W \div R$ equals 0.050, $x = \dfrac{0.0494 + 0.0402}{2} = 0.0448$ inch.

When there are differences in regard to two of the data, the determination of x is a more complicated problem than the above. Take, for example, the case where $N = 31$ teeth, $\beta = 65$ degrees, and $W \div R = 0.030$. In this case, the values of x for 30 and 32 teeth when $W \div R = 0.030$ are first calculated as above, and then their mean is taken as the required value of x. Thus, x for 30 teeth $= 0.1018$ (by above method); for 32 teeth, $x = 0.0911$; and for 31 teeth, $x = \dfrac{0.1018 + 0.0911}{2}$ $= 0.0964$ inch.

This method of determining the value of x for intermediate combinations is sufficiently close for all numbers of teeth above 12, and all the angles of fluting cutters in general use.

* * *

The invention of a new kind of armor-plate is reported from Germany. The peculiarity of the new armor is its extreme lightness as compared with the Krupp armor, while it is said to have equal, if not greater, resisting power. The armor is made of an aluminum alloy faced with a thin hardened steel plate. The naval authorities have made tests and reported favorably upon the new armor, and gun shields made from it have been ordered for one of the new German cruisers.

* This allowance is rather too liberal for large diameters. The allowances for grinding should not be in exact proportion to the diameters, as this gives too large values for cutters of large size. However, the assumption made has no influence on the formulas or on the tables. Anyone who prefers to use a smaller allowance for grinding can do so, and yet make use of the tables.—EDITOR.

MANUFACTURE OF LINCOLN-WILLIAMS TWIST DRILLS

By CHESTER L. LUCAS*

Twist drills are such common tools about a machine shop that it is surprising how little is generally understood about the methods employed in their manufacture. Any machinist can tell how a tap is made and any good toolmaker can make one, but we seldom hear of a twist drill being made in the average shop. This no doubt is due to the special machinery necessary to mill and relieve the flutes properly; therefore the manufacture of twist drills is almost exclusively in the hands of specialists.

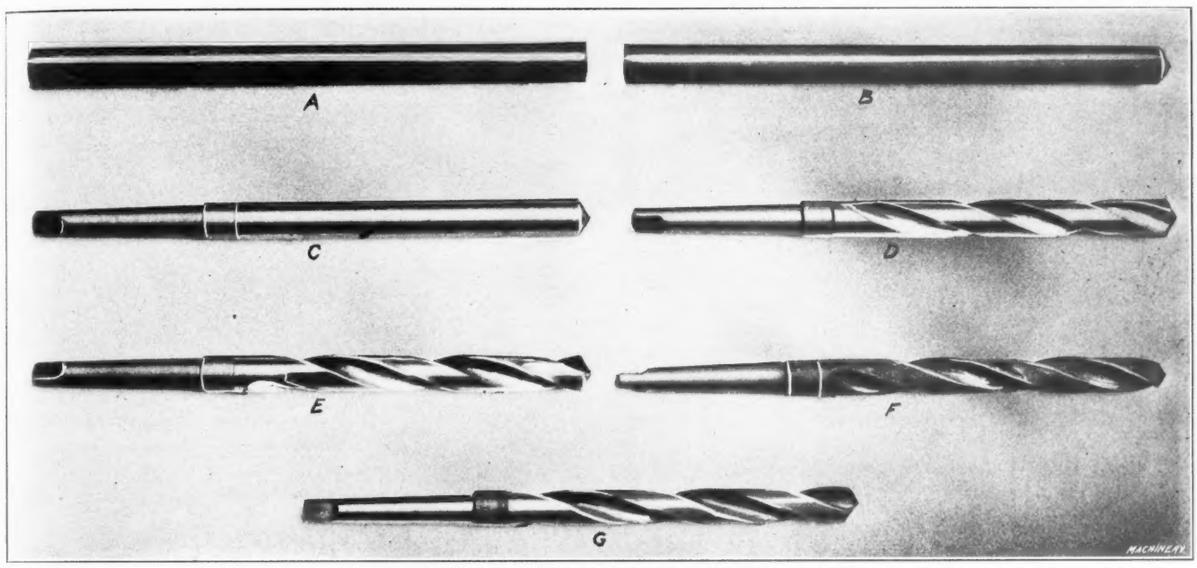

Fig. 1. Results of the Important Operations in Making a Twist Drill

One of the well-known firms in this line is the Lincoln-Williams Co., of Taunton, Mass. The company has moved into a new brick factory of modern design that is well equipped for the manufacture of twist drills. The entire factory is devoted to making this one product, involving the use of much special machinery. Through the courtesy of the management, the writer was allowed to photograph and describe some of the interesting operations connected with the work.

Preparation of the Steel

The stock room in which the steel is stored is kept locked all of the time, and access is permitted to very few men.

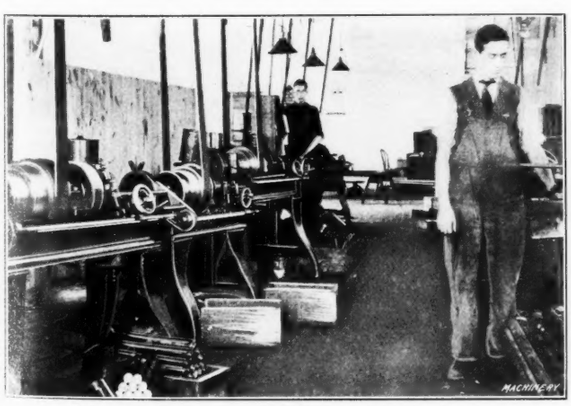

Fig. 2. Cutting off the Stock

The reason for this is to prevent the different brands of steel from getting mixed. As both high-speed and carbon steel are employed in making the various standard and special drills, and as the smaller sizes of drill rod vary but a few thousandths of an inch between sizes, the importance of this precaution is apparent.

Fig. 2 shows the cutting-off department, where the bars are cut to lengths, one of which appears at *A*, Fig. 1. At the left are the cutting-off machines that cut the larger sizes of steel to length. The operator at the right is sharpening a saw for the cold-sawing machine that is used for cutting up some of the steel. For all drills, the steel is selected enough larger than the finish size to admit the turning off of all the "skin" from the outside of the stock.

The lengths of steel are next centered on one end and pointed on the other end to an included angle of 121 degrees. This end of the blank is used as the blade end of the finished drill and obviates the wasting of ¼ inch of steel that would be necessary if centered in the usual way. The blank, centered and pointed, may be seen at *B*, Fig. 1. The smaller sizes of drill blanks are cut off and centered in screw machines, as illustrated in Fig. 3, and the very small drills are cut off and pointed only, no center being required. This work is done in Brown & Sharpe automatic screw machines.

Forging, Annealing and Straightening

A good many drills of the smaller sizes are made with taper shanks that are much larger than the body of the drill, usually with either No. 1 or No. 2 Morse tapers. After being cut off, the stock for such drills is forged down, reducing the blade section approximately to size. This operation is shown in Fig. 4, and of course it is obvious that this treatment improves the steel and results in a better drill.

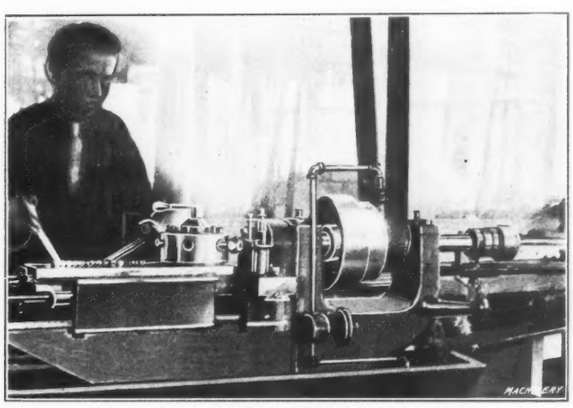

Fig. 3. Pointing and Centering the Drill Blanks

The blanks must now be annealed to facilitate the turning. Fig. 5 shows one of the large oil furnaces in which the blanks are heated. Cast-iron boxes, one of which may be seen being taken from the furnace, are filled with the lengths of steel, covered and sealed and placed in the furnace. Here they are heated slowly for a number of hours and allowed to cool very gradually.

The straightening operation is illustrated in Fig. 6. Here the operator is shown straightening forged blanks. These

* Associate Editor of MACHINERY.

blanks have been centered and pointed. He places a blank between the centers of the bench fixture *A*. gives it a twirl, at the same time noticing the high points with relation to the adjustable rest *B*. To facilitate the work, a screen *C* is placed so as to diffuse the light; when artificial light is needed, it is placed behind this screen. After locating a high point, the operator takes the drill from the centers, places it across the supports of the straightening press *D*, and bends it slightly to straighten it. In view of the fact that the work depends wholly upon judgment, it is surprising how well and how quickly the blanks are straightened. A straightening stand is used for the larger blanks. The stand is surmounted with an iron surface plate upon which the blanks are rolled. This operation shows up the high places and the blanks are straightened in a larger screw press not shown.

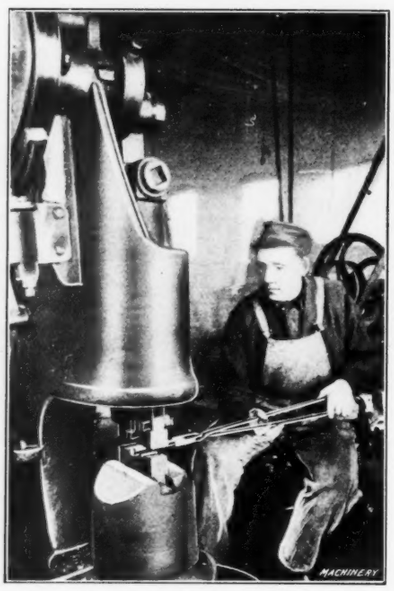

Fig. 4. Forging the Blanks for Special Drills

Rough- and Finish-turning

The small and medium sized drills are turned on lathes like that shown in Fig. 7. The work is held on male and female centers and driven by a dog in the usual way. The tools are made of high-speed steel, and for every turning operation in drill-making in this factory tool-holders with high-speed steel bits are employed. Each lathe performs but a single operation. One lathe rough-turns the shank; the next lathe rough-turns the blade; a third lathe finish-turns the shank and the fourth lathe finish-turns the blade. In turning, an allowance of from 0.005 to 0.007 inch is allowed for the grinding on this small and medium sized work. At *A*, Fig. 7, is a gage for testing the size from time to time. These lathes are fitted with automatic feed-releasing mechanism so that one operator may attend to four machines without trouble. This mechanism consists of a bracket *B*, bolted to the carriage; through this bracket a pin extends downward, coming in contact with arm *C* at the proper time to throw the internal half-nut out of mesh with the lead-screw at the end of the cut.

The operation of turning the large blanks is essentially the same as the smaller work, except that the limits allowed on drills up to 1¼ inch range from 0.008 to 0.012 inch. In a good many instances, the drills are simply rough-turned, and, as shown in Fig. 8, are ground to within the limits allowed for hardening and final grinding. This is quicker than turning and leaves a good surface for the succeeding operations.

Milling the Tangs and Finishing the Ends

Fig. 9 illustrates the method of milling the tang. The drill blank *A* is held in clamp *B*, while the two cutters *C*, which are mounted at the proper distance apart, mill the tang. At *D* may be seen the worm and worm gear that are disengaged automatically at the end of the cut. It takes about half a minute to cut the tang of a ½-inch drill. The partly completed drill now appears as at *C*, Fig. 1.

Another simple operation, shown in Fig. 10, is that of rounding the shank end of the drill. This is done to remove corners and edges that might otherwise become bruised, thus interfering with the fit of the taper shank. The drill blank *A* is held in the clamp *B* and fed into the box-tool *C* that shapes the end of the shank. Both tool and holder are very strong.

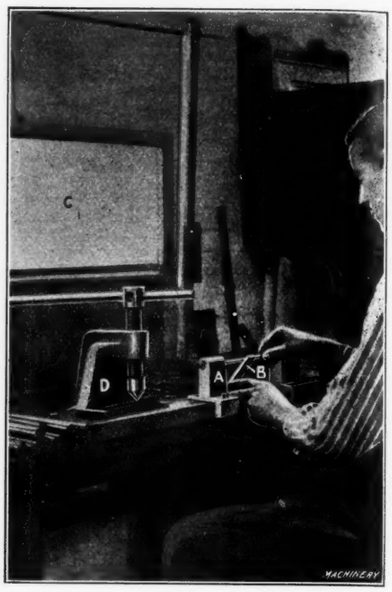

Fig. 6. Straightening the Blanks

Milling the Grooves

One of the most interesting operations connected with the making of twist drills is the milling of the flutes. Fig. 11 shows a small section of the department where the flutes in the large drills are milled. The drill blanks are fed downward to a pair of cutters that simultaneously mill the two grooves. Of course, it is obvious that the drill must turn while the milling operation is being performed, so as to obtain the spiral flutes. These machines are semi-automatic in their operation, so that one operator can keep several of the machines in operation without difficulty. The result of the milling is shown at *D* in Fig. 1.

The method of grooving the small drills is essentially the same, although the machines are of the horizontal type. Fig. 12 shows a row of the machines that are used in milling the grooves in drills under ¼ inch in diameter. By means of the same automatic feed-releasing mechanism as is used on the turning lathes and tang-milling machines, the feed is thrown out at the end of the milling operation. While being milled, the drill is automatically turned to give the spiral cut to the grooves. As the small drills have straight shanks, they may be held by chucks while being milled. In milling, a cutting compound, of borax, lardoleum and water, is used.

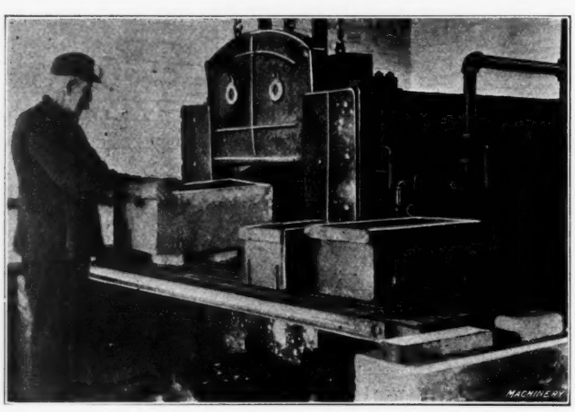

Fig. 5. Annealing the Blanks

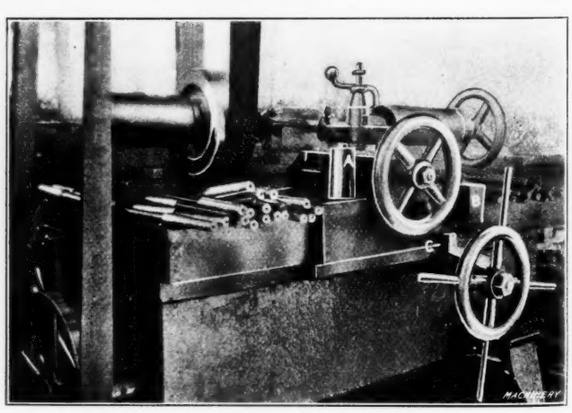

Fig. 7. Turning the Blanks

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Increase Twist

To many men, the meaning of "increase twist" as applied to twist drills is not clearly understood. A drill with increase twist is grooved at a constantly increasing angle of spiral, commencing at the point. This variation in the angle of the groove is brought about by the gradual decreasing of the rate at which the drill blank turns while being fed to the grooving cutters, the forward movement of the drill remaining constant. Thus the "twist" steadily increases. The reason for cutting the grooves with increase twist is to increase the area of the groove as it progresses towards the shank, thus allowing the chips more room to work out of the grooves.

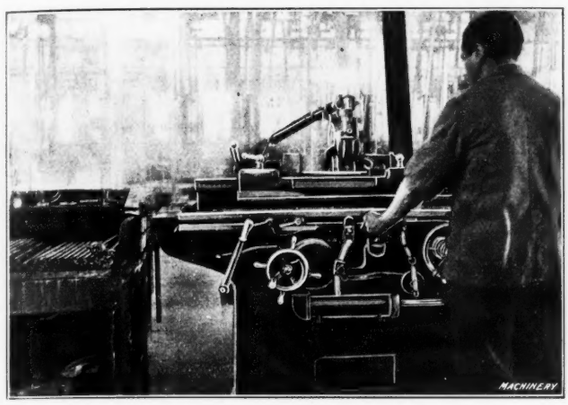


Fig. 8. Grinding the Blade Section, preparatory to Milling

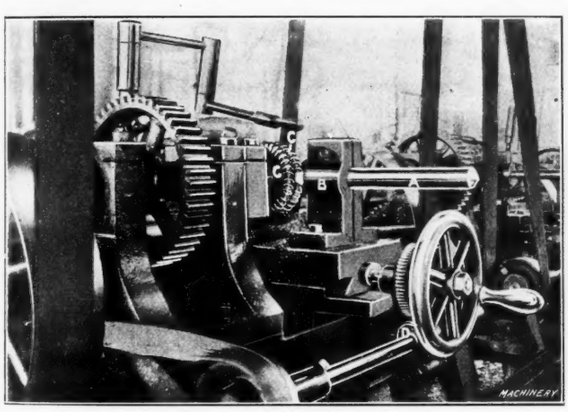


Fig. 9. Milling the Tangs

At first thought it is not quite clear how the increasing of the angle of spiral, or twist, increases the area of the groove. Suppose, to take the extreme view, there were no turning of the drill while being grooved; in such a case it is apparent that the resulting straight groove would be much wider than a spiral groove of any angle. To increase the angle of spiral is to approach the straight line; therefore any increase in the angle of spiral or twist, increases the width of the groove and consequently its area.

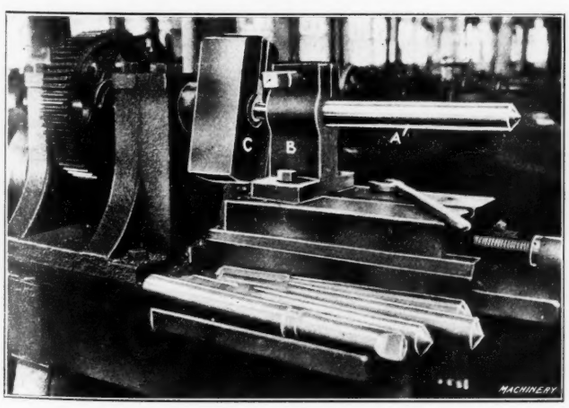


Fig. 10. Rounding the Ends of the Shanks

Milling the Clearance to the Grooves

The edges of the cutting lips of twist drills must be given clearance the same as any other metal-cutting tool. The clearance on Lincoln-Williams drills is milled with cutters; "cutter-cleared" they are termed in the trade. One of the machines for milling clearance may be seen in Fig. 13. The drill is held in the sleeve *A* that runs loosely in tailstock *B*. From the point, it is drawn through bushing *C*, at the same time being slowly turned. Cutter *D* works through an opening in this bushing, removing the clearance. The amount of metal removed for clearance depends, of course, upon the size of the drill, varying from approximately 1/32 inch on the large drills to a few thousandths inch on the smallest drills.

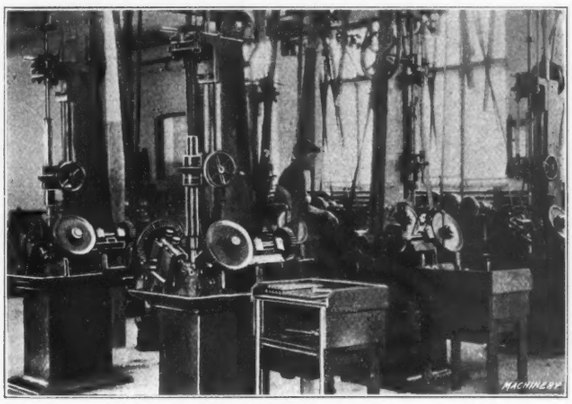


Fig. 11. Milling the Grooves

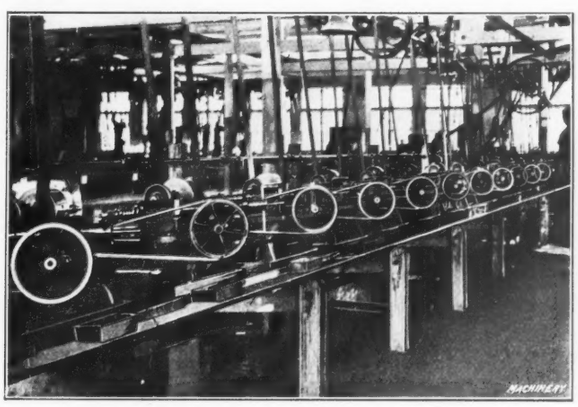


Fig. 12. Milling the Grooves in the Small Drills

The illustration Fig. 14 shows the principle that is followed in "clearing" drills by milling. In a cutter-cleared drill, the stock is milled away in a straight cut, commencing a short distance from the cutting side of the lip and extending parallel to the length of the drill into the groove behind. The result is a clean, even clearance throughout the length of the drill, as may be seen at *E*, Fig. 1.

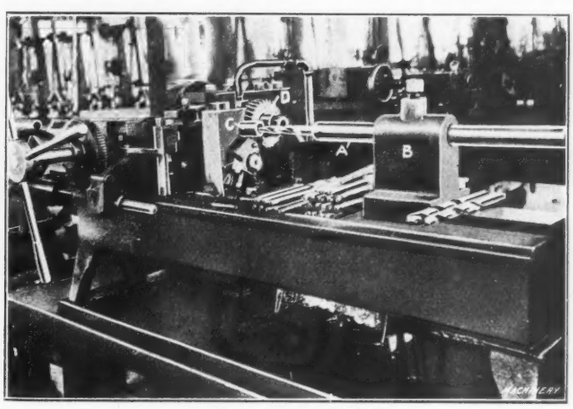


Fig. 13. Clearing the Drills

The ends of the blades of the drills are next relieved, or

sharpened, as we would call it if the drills were ready for use, and then another equally simple operation follows: that of marking the name upon the recess between the shank and blade. The size is also stamped on at this time, and the drills are ready for hardening.

Hardening the Drills

After the clearance has been given to the ends of the lips of the drills they are ready for hardening. Fig. 15 shows a

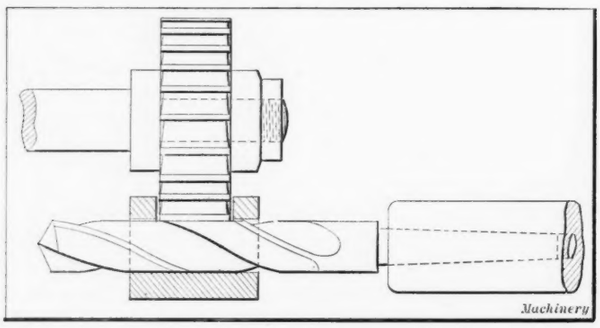


Fig. 14. Details of Clearing Operation

section of the department where the high-speed drills are hardened. The furnaces are all gas furnaces and are of several sizes so as to accommodate the different sizes of drills that must be heated. One of the hardeners is shown heating a drill preparatory to hardening in the oil tank behind him.

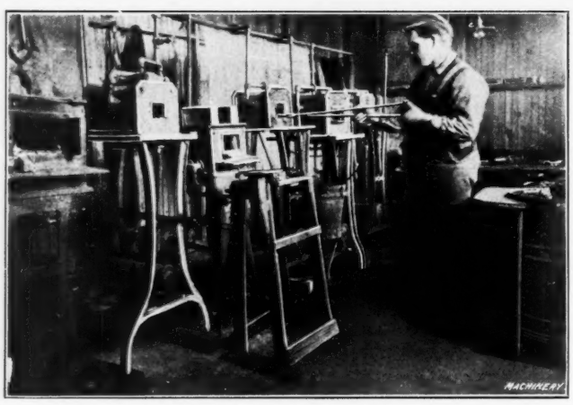


Fig. 15. Hardening High-speed Drills

For hardening these high-speed steel drills the furnaces are regulated to control the heat at approximately 2300 degrees.

In hardening the carbon steel drills, lead pots are used for heating the drills. Fig. 16 shows one of the hardeners at work hardening carbon steel drills. The tank for quenching is an

Fig. 16. Hardening Carbon Steel Drills

ordinary hogshead filled with brine. The brine is kept cool and at a constant temperature by means of a circulation of cold water that passes through a coil of pipe within the brine barrel. This cold water is pumped from the cistern that may be seen in the right foreground of Fig. 16; thus the continuous stream of cold water circulating through the coil maintains an even temperature in the hardening tank.

The special tongs used in hardening small drills may be seen in the background of Fig. 17. These tongs will hold twelve drills so they may be hardened at once. One jaw of the tongs is grooved with twelve parallel grooves, while the other jaw holds a flat spring that has twelve "fingers" that bear upon the drills, compensating for any unevenness in the other jaw. The smaller pair of tongs is for holding small drills, as shown. At the right of this illustration may be seen two lots of small drills that are ready for hardening, and in the foreground is a lot of drills that has just been hardened. Fig. 18 is shown to illustrate the way in which the small drills are hardened. The lead pot is heated from beneath by fuel oil. The surface of the molten lead is kept covered with broken charcoal to prevent the formation of dross. It takes but a few seconds to heat up a row of drills and but a few seconds to

Fig. 17. Special Tongs used in Hardening Small Drills

quench them, so the work proceeds very rapidly. With the above method of even heating, and the constant temperature of the hardening bath, there can be little chance for poorly hardened drills, if the steel is of good quality—and it is.

Oil-tempering the Drills

Hot oil furnishes the best known method of tempering any kind of a tool that requires an even temper throughout its length, and, of course, it is desirable that drills be evenly tempered throughout their lengths. At *A*, Fig. 19, may be seen the tank in which the drills in this factory are oil-tempered. As will be noticed, the tank is on rollers, running on a track above the gas furnace *B*. The drills are placed in an iron basket *C*, lowered into the hot oil, and left there until they have been brought up to the temperature of the oil, which is approximately 450 degrees F. This gives the drills a degree of toughness that it is impossible to attain in any other way. The box *D* contains sawdust for drying the drills after being taken from the hot oil. At *F*, Fig. 1, may be seen the drill after hardening.

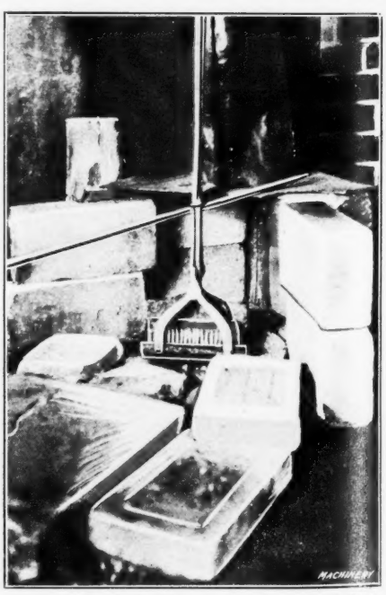


Fig. 18. Method of heating Drills in Lead Pots

Straightening

In spite of all the precautions that are taken to have the drills come from the hardening tank straight, a good many drills will be warped to a more or less degree. To straighten

such drills, they must be heated at the top of the curve and pressure applied. This operation is practically the same as the cold straightening being done in Fig. 6, except that the small drills, under ¼-inch, are straightened on a lead block with a soft metal hammer. Heat is applied with a small gas torch.

Cleaning out and Grinding

After leaving the hardening department, the drills go to the cleaning bench, where they are brushed out with fine emery and oil as shown in Fig. 20. The operator takes three or four drills at once, and holding them at the angle of the flutes, brushes out all of the scale and dirt left by the hardening process.

The final operation in the making of a twist drill is to grind the shank and blade true with the centers, for of course there is bound to be a little distortion, even after straightening. Other reasons for grinding after hardening are to size the drill and give it sharpness throughout the length of the blade. This operation is illustrated in Fig. 21, the finished drill being shown at *G*, Fig. 1.

Inspecting and Testing

After hardening, every drill is examined for fire cracks and tested for hardness. After grinding, each drill is tested for size of blade and correctness of taper in the shank, if the drill is of the tapered-shank variety. In addition, drills are selected at random from the different lots, and tested in actual use, for the Lincoln-Williams Co. believes that the proof of the drills is in the drilling. For this purpose, semi-annealed steel is used, and careful records are kept of the performances of the tested drills.

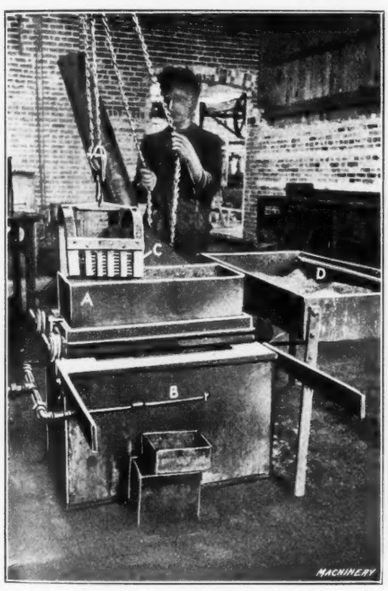


Fig. 19. Tempering Drills

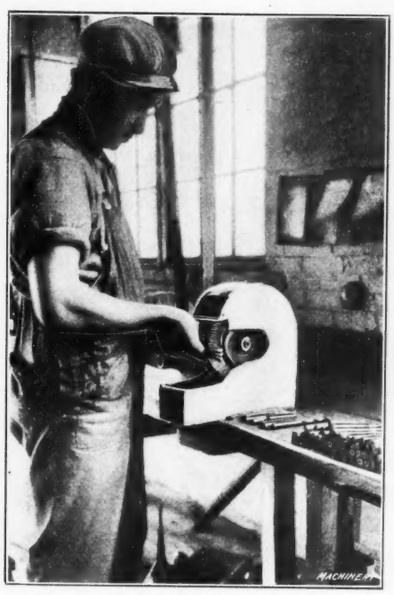


Fig. 20. Cleaning out the Drills

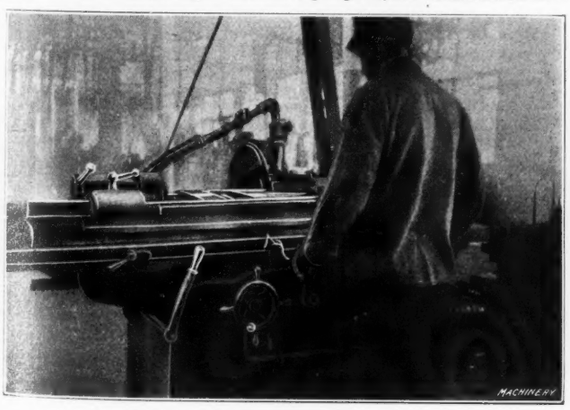


Fig. 21. Grinding the Hardened Drills

Welding Special Shanks

Fig. 22 illustrates the operation of electric welding special shanks to small drills that are used by woodworkers in bit-braces. The special square shanks are first forged; the drills are made and hardened and the last operation is to weld the two parts together. The drill is held in the spring collet that is closed by handwheel *B*. Several of these collets, which are made of copper, may be seen in the block *G*. At *E* is a rack of drills and at *F* may be seen a box of shanks. The shank is held in the head *A* of the machine. The current quickly brings each part to a welding heat; handwheel *C* runs the head of the machine forward, uniting the two parts while at a white heat. The operation of the head, by means of the handwheel, automatically admits and cuts off the current that comes through the coil at *D*. By means of the handwheel that may be seen at the right of the coil, the amount of current may be regulated to suit any of the sizes of drills that are required to be welded to special shanks. With this machine, approximately 4000 drills may be welded per day of ten hours.

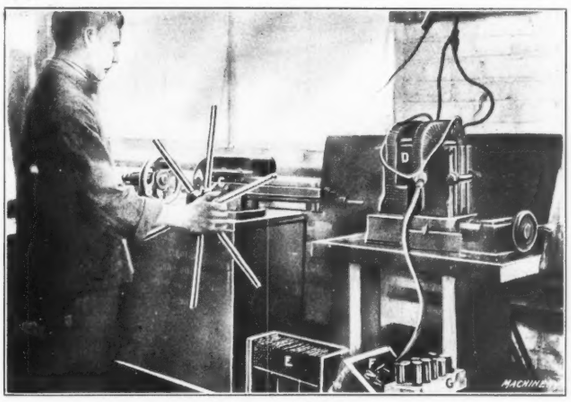


Fig. 22. Welding Special Shanks to the Blades

* * *

GASOLINE OR OATS?

Many persons who have studied the case of the auto *vs.* the horse are of the opinion that within ten years the use of horses will be forbidden upon the streets in the congested parts of cities. One of these experts asserts that by 1920 not a horse will be allowed south of Fourteenth St. on Manhattan Island. Another authority says that today the horse is hampering business in all the crowded delivery sections of cities and that horse-drawn vehicles take up so much room that in New York City alone, if the horse were done away with, three hundred miles of streets could be saved.

It is all a question of dollars and cents, this gasoline or oats proposition. Even with an ordinary pleasure automobile it simmers down to that. Tests have shown that the balance is in favor of the motor-car just as it is in the case of the heavier vehicles that do the truck-horse work. A six days' trial, for purposes of comparison, was made not long ago. The automobile ran four hundred and fifty-seven miles in that time at a cost of one and one-half cent per passenger per mile. Depreciation was charged in this cost, too. With a horse and buggy the distance covered in the six days was one hundred and ninety-seven miles and the cost was nearly two cents per passenger per mile.—*Harper's Weekly.*

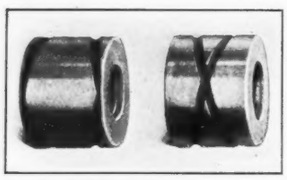
* * *

The National Twist Drill & Tool Co., Detroit, Mich., uses a simple method of etching on cutters and other tools. The steel is brushed with asphaltum varnish which is allowed to stand a few minutes until it thickens and hardens to the right degree. Then the desired inscription is pressed through the asphaltum with a rubber stamp and the etching fluid (aqua regia) is applied with a medicine dropper. Good results are obtained, but some practice and experience are required to judge just when the varnish has dried to the right consistency.

OIL GROOVE CUTTING TOOL*

A SPECIAL TURRET TOOL FOR THE BROWN & SHARPE AUTOMATIC SCREW MACHINE

By DOUGLAS T. HAMILTON†



Oil-grooved Pin

Cutting a helical oil groove in a cylindrical piece of work in the Brown & Sharpe automatic screw machines is a feat, the successful accomplishment of which demonstrates some of the possibilities of these machines in the hands of a resourceful designer. A turret tool for performing this work was designed by the Brown & Sharpe Mfg. Co., and was used for cutting an oil groove in a needle bar connection pin for the Wilcox & Gibbs sewing machine. This turret tool, which is illustrated in Figs. 1, 2, 3 and 4, is designed on the generating crank principle, so that the cutting tool is moved back and forth in a straight path parallel with the axis of the work while the latter is rotating. The cutting tool while

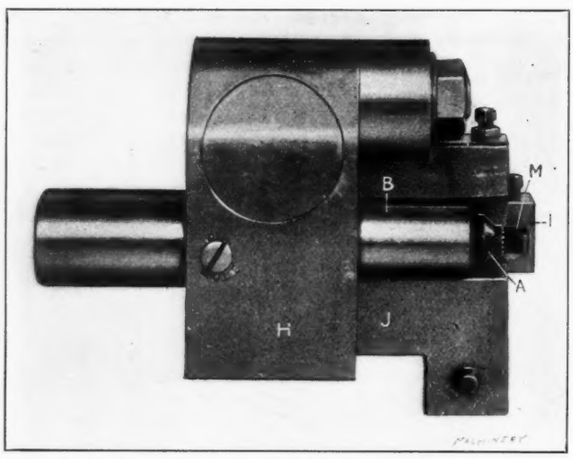


Fig. 1. Oil Groove Cutting Tool showing Driver and Cutter

being longitudinally traversed is at the same time fed into the work to the desired depth by means of a rising block held on the cross-slide.

Operation of the Oil Groove Cutting Tool

The oil groove cutting tool shown in Figs. 1, 2, 3 and 4 is operated in the following manner: After the end of the work

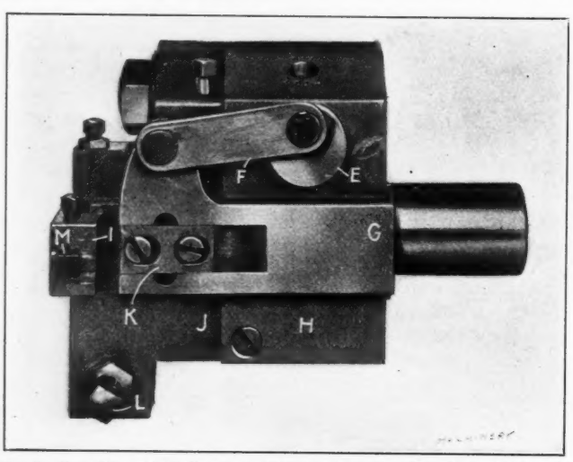


Fig. 2. Rear View of Oil Groove Cutting Tool showing Crank- Tool-slide, etc.

has been knurled, the turret is advanced, bringing the driver *A* into contact with the knurled end of the work. The rotating motion of the work is transmitted by driver *A* to spindle *B*, the latter being connected to the driver by a pin *C* fitting in an elongated hole in the spindle. The spindle *B* is provided with helical teeth that mesh with the helical gear *D*, held on a shaft *E* to which link *F* is eccentrically connected. The other end of link *F* is pivoted to the crank-slide *G*, which fits in a V-groove cut in the main body *H*. The tool-slide *I*, which fits in a V-groove in the swinging member *J* is connected to the crank-slide *G* by a tongued block *K* held by two screws in a slot cut in the crank-slide.

When the driver *A* is in contact with the work, the front cross-slide is advanced and the rising block coming in contact

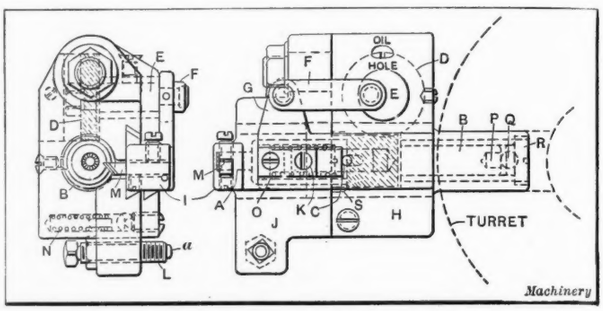


Fig. 3. End and Side Elevations of Oil Groove Cutting Tool

with the end *a* of the set-screw *L* forces in the swinging member *J* carrying the turning tool *M*. While this is taking place, the turning tool is being traversed back and forth by means of the crank mechanism, and thus produces the helical groove in the work. Upon the completion of the oil groove, the cross-slide drops back, and the coil spring *N* returns the swinging member to its former position; and when the turret drops back, the coil spring *O* returns the driver *A* to its "out" position.

Construction of the Oil Groove Cutting Tool

This tool embodies some features in its design which could be incorporated in other turret tools of the generating type,

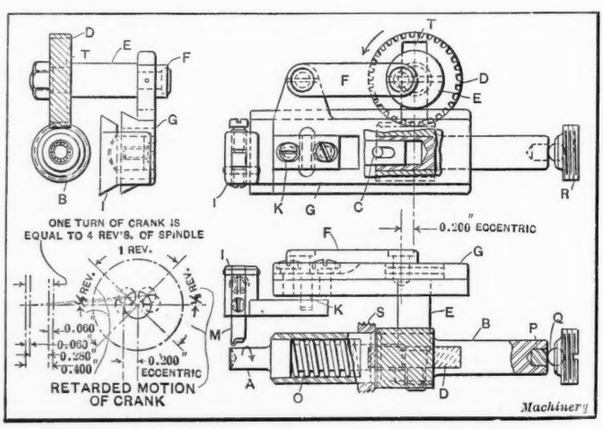


Fig. 4. Diagram showing Operation of the Oil Groove Cutting Tool

so that a description of its construction might be of value. Referring to Figs. 3 and 4, it will be seen that the driver *A* is countersunk and knurled on the end, and is provided with a shoulder against which the spring *O* abuts. The driver is prevented from coming out of the spindle *B* by a pin *C*, driven into the former and fitting in an elongated hole in the spindle. This pin also acts as a stop to prevent further movement of the driver *A*, when it has once come in contact with the work.

The driving spindle *B* is made from machine steel, counterbored to receive the driver *A*, and provided with helically cut teeth. To take the thrust of the driver coming up against the work, the rear end of the spindle is provided with a hardened block *P*; this block bears against a ball *Q* held in the nut *R*, which is screwed into the shank of the holder. The spindle is retained in the main body *H* by a hollow-nut *S*, and runs in a phosphor-bronze bearing. The helical gear *D* is held on the end of the crank stud *E* which runs in a phosphor-bronze bearing, by a nut as shown, and is retained in the

* For a description of other tools on the generating principle, built by the Brown & Sharpe Mfg. Co., see the following articles: "Cutting Helical Gears on the Brown & Sharpe Automatic Screw Machines, April, 1909; and "Attachment for Cutting Helical Steel Gears," August, 1909.

† Associate Editor of MACHINERY.

correct relation to the eccentric by the slot T which fits the flattened sides of the stud.

As the swinging member carrying the tool-slide must have a slight movement across the face of the main holder, it is necessary that the two slides be flexibly connected. This is accomplished by inserting a block K, which is provided with a tongue to fit in the slot cut in the crank-slide G. The tongue extends down through an elongated slot in the slide, and fits in a corresponding slot in the tool-slide I. The slot in slide

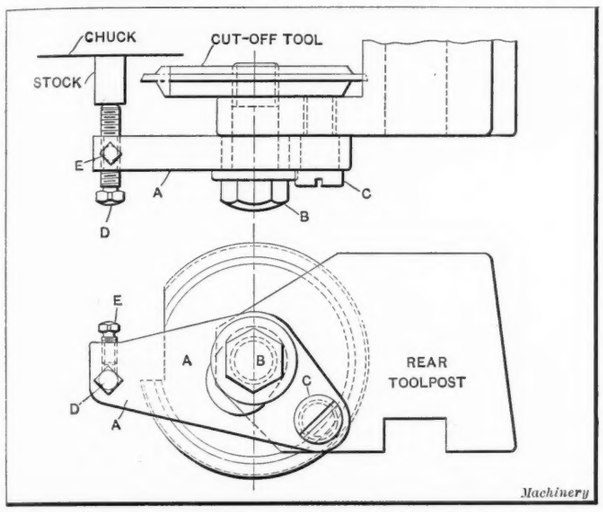


Fig. 5. Stop used on the Rear Cross-slide for Gaging the Stock to Length

G is greater in width than the tongue on the block K so that a slight adjustment for the tool-slide is provided. This adjustment makes it possible to start the cutting tool in the correct relation to the end of the work and the driver.

Obtaining the Throw of the Crank

Referring to the illustration Fig. 7, where a sample of the work is shown at A, it will be seen that the oil groove is to make one complete revolution in 0.282 inch for both forward

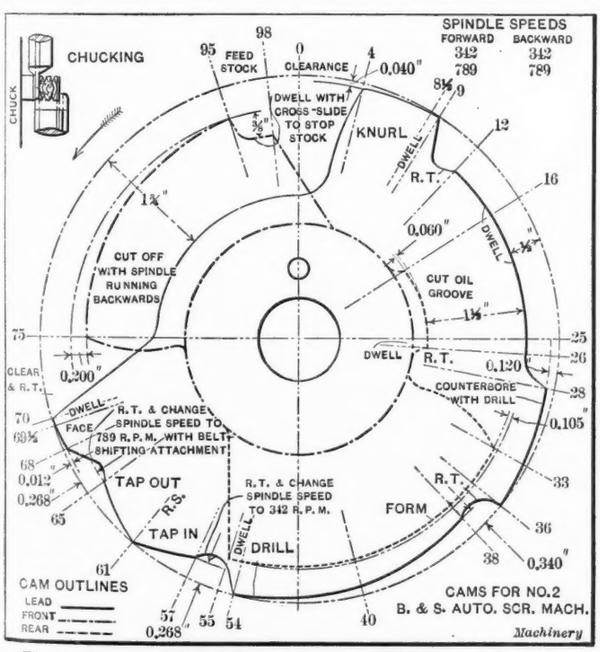


Fig. 6. Cams used in Making and Cutting the Oil Groove in the Needle Bar Connection Pin shown at A in Fig. 7

and return strokes, giving two revolutions in all. The path of the oil groove is more clearly shown in the initial illustration. Now it is evident that the speed at which the tool-slide travels must be less than that at which the work is rotating, or in other words, the work must make four revolutions when the crank is making one complete turn. The helical gears are therefore made in a ratio of 4 to 1.

As this tool is operated by a crank mechanism, it follows that the cutting tool is given a variable movement; that is, it starts up slowly, then increases in speed as it approaches the center, and decreases in speed as it reaches full throw, the same movement being repeated on the return stroke. To obtain the required throw of the eccentric, construct a square having sides equal in length to 0.282 inch, and circumscribe a circle about it. The radius r of this circle, see B, Fig. 7, will then equal the required amount of throw of the crank. The radius r is found by the following formula:

$$r = \frac{\frac{0.282}{2}}{\sin 45 \text{ deg.}} = \frac{0.141}{0.707} = 0.200 \text{ inch approximately.}$$

Referring to the diagram in the left-hand lower corner of Fig. 4, it will be seen that the first one-eighth revolution of

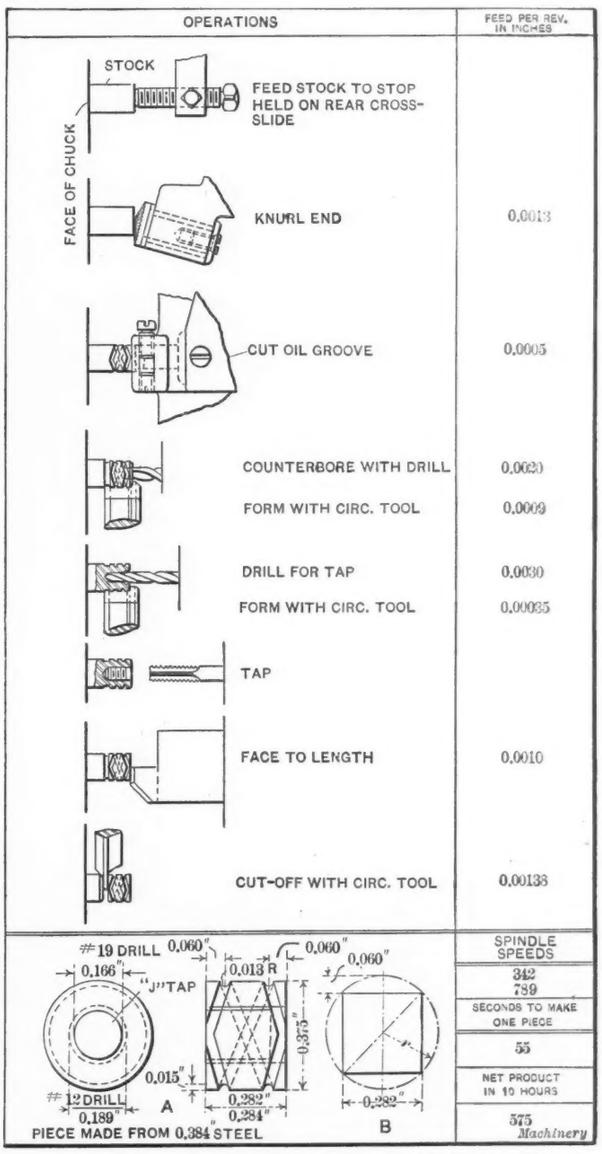


Fig. 7. Order of Operations and Feeds used in Making the Needle Bar Connection Pin

the crank, which equals one-half revolution of the work, gives a longitudinal movement to the tool of about 0.060 inch. The next revolution of the work (or one-quarter revolution of the crank) gives a movement of 0.280 inch, while the remaining forward movement gives a travel of approximately 0.060 inch. The same movement is given to the tool on the return of the crank, the complete travel of which is 0.400 inch. The groove produced by the tool when its motion is retarded is not required. Hence, when the piece is faced and cut off to 0.282 inch, it leaves an oil groove which makes two complete revolutions around the work. The two half revolutions of the groove on each end are removed by the facing tool held in the turret and the circular cut-off tool on the cross-slide.

The chart, Fig. 7, illustrates the tools used and the order in which they are applied. By a close inspection of this chart it will be seen that the turret is full of tools, so that it is necessary to provide some other means for gaging the stock to length. This is accomplished by fastening a block *A* to the rear toolpost as shown in Fig. 5. This block *A* is furnished with an elongated slot so that it can be swung up out of the way to remove the short piece of the bar left in the chuck when it is exhausted. The slot straddles the body diameter of the clamping screw *B*, which is used in holding the circular cut-off tool to the toolpost. The toolpost is drilled and tapped to receive the shoulder screw *C*, which acts as a fulcrum for the block *A*. In the forward end of the block *A* is held a screw *D* which acts as a stop for the stock. This screw is held when adjusted to the correct position by a set-screw *E* bearing upon a brass shoe, which prevents the thread on the screw *D* from being bruised.

Order of Operations

The order of operations followed in completing the needle bar connecting pin is shown in Fig. 7. The first operation is to feed the stock to the stop; then the rear cross-slide drops back and the knurling tool is brought in and knurls the end of the work. The turret is now revolved, bringing the oil groove cutting tool into operation which produces the oil groove. The turret dwells, holding the driver in contact with the work while the swinging member is being advanced by the rising block on the front cross-slide, which feeds the tool in to the correct depth. While this is taking place the toolslide, of course, is driven back and forth across the face of the work by the crank mechanism.

After the oil groove is completed, the turret is again revolved and the drill is brought in to counterbore the front end of the work. The turret is then revolved to bring the tapping size drill in, which drills a hole completely through the work. While the drilling is being accomplished, the front cross-slide is advanced, bringing the circular form tool into operation, which turns down the work to the correct outside diameter. The cross-slide then backs out of the way and the turret is revolved, bringing the tap into operation. After the tapping is completed, the turret is again revolved and the work faced to the correct length by a facing tool held in the turret. After this, the rear cross-slide advances, holding the circular cut-off tool, which severs the completed piece from the bar.

The cams used in making this piece are shown in Fig. 6, where the uses of the various lobes are clearly indicated. It will be noticed that four one-hundredths of the cam surface is allowed between the points where the turret dwells with the oil grooving tool and the cross-slide begins to force the cutting tool into the work. This amount of clearance is necessary because of the relative positions of the lead and the cross-slide levers. The procedure to follow in designing a set of cams for performing operations accomplished by swing tools was illustrated and described in the article entitled "Internal Cutting Tools" which appeared in the November, 1910, number of MACHINERY.

* * *

A petrol-electric omnibus has been introduced in London and extensive tests have been made with it. It is fitted with a four-cylinder engine driving a dynamo which, in turn, supplies the driving current for the motors of the vehicle. The advantages of the design over the regular gasoline engine omnibus are said to be that considerable economy in the use of fuel is possible, that the control of the vehicle is made simpler and more effective, and that the arrangement increases the life of the engine, as the shocks from clutching and de-clutching, which are ordinarily so destructive, are eliminated.

* * *

A maker of twist drills investigated a complaint of a customer who had split several drills in drilling a drop forging. He found that the forging was made with a depression in the center where the hole was drilled, but the depression was of a lesser included angle than the standard drill angle of 118 degrees. The result was that the lips of the drill "hogged in" without having a support for the point. Splitting was inevitable. Changing the angle of the drill to conform to the angle in the forging stopped the trouble.

THE PROBLEM OF FOUR TANGENT CIRCLES*

By WILLIAM W. JOHNSON†

The problem of four tangent circles is as follows: Given three circles and the distances between their centers, to find the radius of a circle which is tangent to the three given circles.

This problem sometimes is met with in practical mechanics. For example, it may be required to find the diameter of a gear which will mesh with three given gears, the diameters

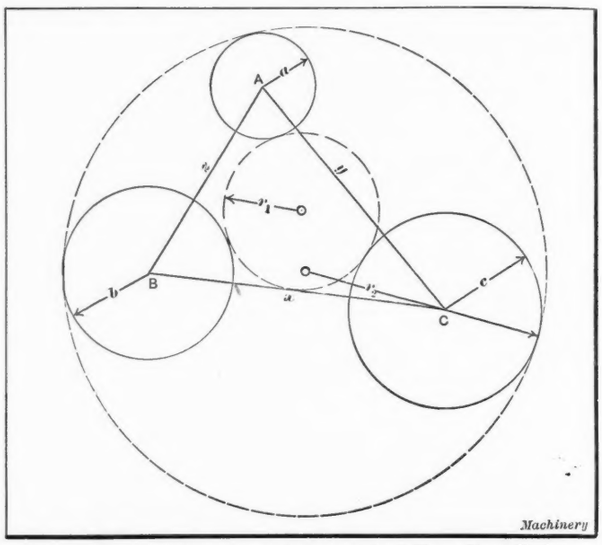


Fig. 1. Circle making Internal Contact with all Three Given Circles, and Circle making External Contact with all Three Circles

and the distances between the centers of which are given. The purpose of this article is to show how general formulas may be derived for calculating the diameter of a circle which is tangent to three given circles. There are not less than eight circles which meet the requirements: One, making internal contact with all three circles (see Fig. 1); one, making external contact with all three circles (see Fig. 1); three, making external contact with two circles and internal contact

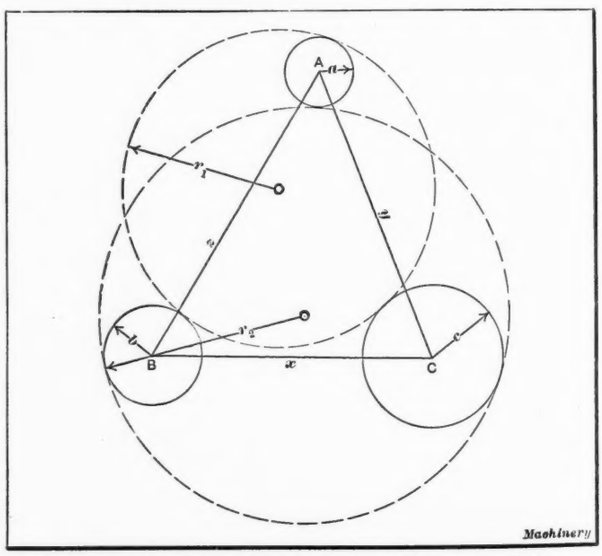


Fig. 2. Circles making Internal Contact with One or Two of the Given Circles

with one circle (see Fig. 2); three, making external contact with one circle and internal contact with two circles (see Fig. 2).

Referring to Fig. 3, let *A*, *B*, and *C* be the centers of the three given circles whose radii are *a*, *b* and *c*, respectively,

* See MACHINERY, March, 1906, How and Why columns, and May, 1906, engineering edition, "The Problem of Touching Circles."

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and let $BC = x$, $AC = y$ and $AB = z$; find r. We can get an equation of the second degree as follows:

Let $AO = p$, $BO = q$, $CO = s$, and angle $AOB = \theta$, angle $BOC = \phi$, and angle $COA = \psi$. Then, $\theta + \phi + \psi = 360°$; $\theta = 360° - (\phi + \psi)$, and $\cos\theta = \cos(\phi + \psi) = \cos\phi\cos\psi - \sin\phi\sin\psi$, or $\cos\theta - \cos\phi\cos\psi = -\sin\phi\sin\psi$.

Squaring both sides we get:

$$\cos^2\theta - 2\cos\theta\cos\phi\cos\psi + \cos^2\phi\cos^2\psi = \sin^2\phi\sin^2\psi = (1-\cos^2\phi)(1-\cos^2\psi) = 1 - \cos^2\phi - \cos^2\psi + \cos^2\phi\cos^2\psi.$$

Hence, $\cos^2\theta + \cos^2\phi + \cos^2\psi - 2\cos\theta\cos\phi\cos\psi = 1$. (1)

From the cosine formulas in trigonometry we get:

$$\cos\theta = \frac{p^2+q^2-z^2}{2pq} = 1 + \frac{(p-q)^2-z^2}{2pq}$$

$$\cos\phi = \frac{q^2+s^2-x^2}{2qs} = 1 + \frac{(q-s)^2-x^2}{2qs}$$

$$\cos\psi = \frac{s^2+p^2-y^2}{2sp} = 1 + \frac{(s-p)^2-y^2}{2sp}$$

Put, in the numerators, $p = r + a$, $q = r + b$, and $s = r + c$; then:

$$1 + \frac{(p-q)^2-z^2}{2pq} = 1 + \frac{(a-b)^2-z^2}{2pq} = 1 + \frac{A}{2pq}$$

$$1 + \frac{(q-s)^2-x^2}{2qs} = 1 + \frac{(b-c)^2-x^2}{2qs} = 1 + \frac{B}{2qs}$$

$$1 + \frac{(s-p)^2-y^2}{2sp} = 1 + \frac{(c-a)^2-y^2}{2sp} = 1 + \frac{C}{2sp}$$

Substituting these values in Equation (1), we get

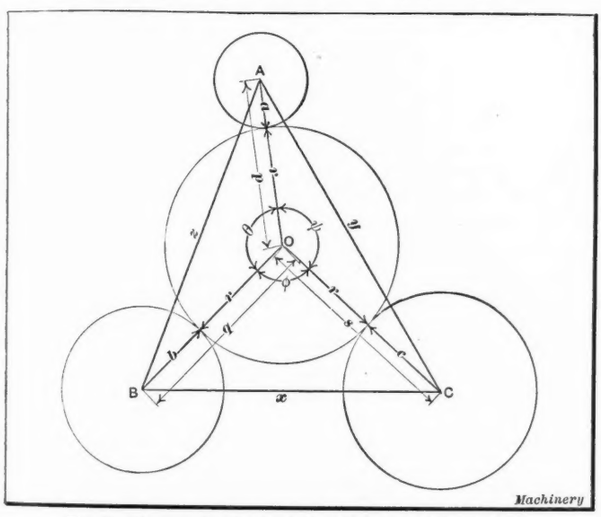

Fig. 3. Diagram for the Analytical Solution of the Problem

$$A^2s^2 + B^2p^2 + C^2q^2 - 2ABsp - 2BCpq - 2CAqs - ABC = 0. \quad (2)$$

Putting $p = r + a$, $q = r + b$, and $s = r + c$, in Equation (2), we get:

$$r^2[A^2 + B^2 + C^2 - 2AB - 2BC - 2CA] + 2r[A^2c + B^2a + C^2b - AB(a+c) - BC(a+b) - CA(b+c)] + [A^2c^2 + B^2a^2 - C^2b^2 - 2ABca - 2BCab - 2CAbc - ABC] = 0. \quad (3)$$

This is the general equation, from which two values for r are always found; one applies to the internal and one to the external circle, Fig. 1.

When $p = r - a$, $q = r + b$, and $s = r + c$ an equation for two other values of r, which apply to Fig. 2, is obtained. When $p = r + a$, $q = r - b$, and $s = r + c$ an equation for two other values is found, and when $p = r + a$, $q = r + b$ and $s = r - c$, an equation for the last two values of r, Fig. 2, is obtained.

By following the same procedure as in the foregoing, and substituting the values for p, q, and s just given, we get as the general equation for the conditions in Fig. 2 ($p = r - a$):

$$r^2[A^2 + B^2 + C^2 - 2AB - 2BC - 2CA] + 2r[A^2c - B^2a + C^2b - AB(c-a) - BC(b-a) - CA(b+c)] + [A^2c^2 + B^2a^2 - C^2b^2 + 2ABca + 2BCab - 2CAbc - ABC] = 0. \quad (4)$$

The other two formulas may be obtained by changing the letters in cyclical order, *i. e.*, changing a to b, b to c, c to a, and x to y, y to z, and z to x. Care must be taken in using the formulas to substitute the values exactly as they appear in the figure. For instance, x is the length of the side opposite the circle of radius a, etc.

Application of the Formulas

In Fig. 1 let $a = 3$; $b = 5$; $c = 6$; $x = 12$; $y = 13$; $z = 10$. Using Formula (3):

$$A = (a-b)^2 - z^2 = -96$$
$$B = (b-c)^2 - x^2 = -143$$
$$C = (c-a)^2 - y^2 = -160$$

Coefficient of $r^2 = A^2 + B^2 + C^2 - 2AB - 2BC - 2CA = -48{,}671$.

Coefficient of $2r = A^2c + B^2a + C^2b - AB(a+c) - BC(a+b) - CA(b+c) = -230{,}909$.

Absolute term $= A^2c^2 + B^2a^2 + C^2b^2 - 2ABca - 2BCab - 2CAbc - ABC = 1{,}250{,}089$.

This gives the quadratic equation

$$48{,}671\,r^2 + 2(230{,}909)\,r - 1{,}250{,}089 = 0$$

Solving for r we find:

$$r_1 = 2.1978, \text{ and } r_2 = -11.6864.$$

In Fig. 2 let $a = 1$; $b = 2$; $c = 3$; $x = 7$; $y = 6$; $z = 5$. Using Formula (4):

$$A = (a+b)^2 - z^2 = -16$$
$$B = (b-c)^2 - x^2 = -48$$
$$C = (a+c)^2 - y^2 = -20$$

Coefficient of $r^2 = A^2 + B^2 + C^2 - 2AB - 2BC - 2CA = -1136$.

Coefficient of $2r = A^2c - B^2a + C^2b - AB(c-a) - BC(b-a) - CA(b+c) = -4832$.

Absolute term $= A^2c^2 + B^2a^2 + C^2b^2 + 2ABca + 2BCab - 2CAbc - ABC = 26{,}176$.

This gives the quadratic equation:

$$1136r^2 + 2(4832)r - 26{,}176 = 0.$$

Dividing by 16, reduces to:

$$71r^2 + 2(302)r - 1636 = 0.$$

Solving for r, we find:

$$r_1 = 2.1601 \text{ and } r_2 = -10.6671.$$

* * *

DOUBLE-CUTTING PLANERS

A planer for cutting on both the forward and return stroke has been developed by Joshua Buckton & Co., Leeds, England, and was described in a paper read by Mr. J. Hartley Wicksteed at a recent meeting of the Institution of Mechanical Engineers. Many attempts have been made in the past to adapt the planer to double-stroke cutting, but the objection has always been made that with an equal speed of the planer table on both the forward and return strokes, the absence of a quick return motion on the idle stroke in such cases where the work does not permit of the use of both tools, on account of lack of clearance at the end of the stroke, discounts the advantages gained on work where double-cutting could be employed. This objection is overcome in the double-cutting Buckton planer by adopting for the drive a variable speed motor and using a small auxiliary motor for such operations as feeding and traversing the tools. A special advantage of the Buckton arrangement is, therefore, that it is flexible, so that either the forward and return strokes can be made at a uniform speed, or the return stroke can be made at an increased rate of speed when required. Another design has also been introduced with belt drive to the planer, by means of which the same flexibility as regards the rate of speed of the return stroke can be obtained. The method of holding the double-cutting tools is to fasten them back to back and exactly in line.

* * *

In painting or otherwise coloring the walls of any workroom, this question naturally arises: What color reflects the most and what the least light? Here are the data, based on recent experiments in Germany. Dark blue reflects 6½ per cent of the light falling upon it; dark green about 10 per cent; pale red a little more than 16 per cent; dark yellow, 20 per cent; pale blue, 30 per cent; pale yellow, 40 per cent; pale green, 46½ per cent; pale orange, nearly 55 per cent; *pale white, 70 per cent.* Glossiness and varnish increase the amount of light reflected.—*Detroit-Fenestra.*

THE CINCINNATI METHOD OF INDUSTRIAL EDUCATION—A FRIENDLY CRITICISM*

By JAMES A. PRATT†

The writer recently visited Cincinnati with the purpose of becoming acquainted with the work done there along the lines of industrial education. An opportunity was afforded to visit four very well equipped plants, attention at these visits being given solely to the mechanical engineering and machinist's shop courses there provided in connection with studies at the Cincinnati University or the apprentice continuation school. In each case the writer made his purpose clearly known, and requested the privilege of talking with the students.

The Course for the Students of Mechanical Engineering

In order to obtain an idea of the practical shop knowledge assimilated by the students, a number of questions of the character indicated below were put to them.

What is the advantage of the floating collet as used in small tool design?

In assigning work to the boring mills, what general division would you make between that going to the horizontal mill and that going to the vertical?

What factors would you consider in deciding whether a casting should be made from a full pattern or swept up?

Assuming that you were running a certain mixture, which had previously given satisfaction, in the cupola, and you unexpectedly found your casting coming hard, what would be your line of procedure to determine the cause of the difficulty?

These are questions which with proper shop teaching in engineering, students should be able to answer. Out of five men, however, but one was able to give passable answers to questions of this kind. This man was in the fifth year of the course, and yet, on certain phases of shop work, he could answer no questions, as many subjects had never been taken up at all. According to his own statement, this young man has never been asked, throughout the five years of his course, to make a shop report of any kind to a college authority.

The work done by the engineering students in the shop is in no way different from that given to the ordinary mechanic. It is evident that great breadth of view and ability would result if a man studying to become an engineer could at the same time be trained to be a thorough mechanic in at least one of the trades, while he was given a fair degree of familiarity with all the other trades bearing on his profession. Such a plan, however, could not be carried into effect in much less than seven years entirely devoted to understudy work, not including the three or four years of preparatory work required, and few persons are willing to spend this length of time in training, especially as it is not absolutely necessary for the engineer to be a skilled mechanic.

Since, therefore, some details of the shop work must be dropped from the course of training, which should these be? Logically it would appear that those details which develop dexterity to a greater degree than they impart knowledge of tools and processes, could be eliminated with the least danger. What the student requires most, in order to tell in the future when a man, or a gang of men, is working efficiently, is to understand the purpose and efficient operation of various machines. Outside of this the shop work of the engineering student should have in view the development of his ability to solve engineering shop problems, rather than to train him to be a skilled mechanic. However, the writer was told by a person in authority at one of the shops visited that no attempt was made to give the engineering students any other class of work than was given a boy who was learning a trade.

The manufacturer is surely not to blame for this condition. He is not running an educational institution, and his position was presented clearly by the statement of one manufacturer who said that the manufacturers were glad to have the boys get anything that they could out of the scheme, but no special shop arrangement would be permitted for the benefit of the engineering students. From a business point of view this position is not open to criticism, nor can those in charge of the plants be expected to act otherwise. There is, however, a reason for discussion when the claim is made by educators, that the scheme, as worked out, is a full and satisfactory substitute for proper college shop training. Such a claim is made by those responsible for this method of training in Cincinnati. It is admitted by the writer that there is a great deal of college shop work which does not give the student any better view of actual shop work, nor perhaps as good, as that obtained by the Cincinnati students, but such conditions exist only because of incompetence or indifference on the part of the educators, and this neglect cannot be excused. In any event, the training as obtained by the students in Cincinnati—so far as the work was shown to the writer—does not give a sufficiently broad training, because the student must do the work wanted in the plant regardless of whether it benefits him or not, and, further, some of the plants do not maintain all the departments in which training is usually considered essential to the engineer.

The Coordinator

In visiting the plants it was expected that the coordinator would be met with and an opportunity afforded to talk over this matter with him. The writer had expected that he made frequent calls on the boys while at work. In the first shop visited, however, a man having such duties as ascribed to the coordinator was not known, and the most precise statement obtainable was that a man came around once in awhile, and if a student was kept too long on one job he tried to get him changed. The students interviewed said that there was no connection between the work in the shop and the studies in the college. In theory the coordinator may be clearly defined and his purpose fixed, but as far as ascertainable, the practical results of his work are not effective, since he has no authority over the students or their work in the shop. It is, therefore, open to question whether the cooperative plan is an efficient substitute for proper college shop work, especially since even under the best conditions there is much that is necessary for an efficient training which is not presented.

In three of the four plants visited, it was stated that the students, under the cooperative system, were not to work except in the machine shop, no pattern shop, foundry nor forge shop training having been arranged for. The reason for this was that these plants did not have such departments, work of this character being done for them by outside firms. In another case an engineering student stated that upon authoritative advice he was omitting training in the pattern shop and foundry, because these branches were unnecessary as a part of a mechanical engineer's course.

Apprenticing Engineers

Literally, an attempt is made in Cincinnati to apply the apprenticeship method of teaching engineering. This plan would be satisfactory if the shop work were supervised in such a way that the student covered the proper field in a correct manner, and providing only a small number of students were to be handled. As soon as a large number are placed under such a plan, the training is likely to be insufficient, because there is not enough of the proper kind of work in any one plant to meet the student's needs. The point where there is a surplus of students to permit proper training has evidently been reached in Cincinnati, if it be true, as it is stated, that there are two courses available to students, one under which he can agree to a contract at a certain wage rate, according to which contract the company must place him in all of its departments, and one under a later form of contract where there is no agreement on the part of the employer to afford experience to a student in more than one department of a shop; but in this case a higher wage scale is offered. The writer did not see the latter contract, but was told that such a course was taken by many. This method permits of the entry of a larger number of students to the course, but it does not give them an efficient training.

There are certain excellent features of the engineering shop work as practiced in Cincinnati, one of which is the association with the workmen; but the most important feature of all—that the training of the student should be carried on without curtailment until the requirements of the course are met with in full—is being neglected. There is no department of a technical school which may be used so effectively as the shop in developing executive ability, provided the shop course is properly managed; and the factor of the development

* For previous articles on the Cincinnati plan of industrial education, see "Industrial Education—The Cincinnati Plan," November, 1909, and "Cooperative Industrial Education," October, 1908.

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of executive ability should be kept well in mind by all who are training young engineers. Yet this feature is entirely lacking in the method applied in Cincinnati.

Summary

Summing up the points in favor of the Cincinnati plan and the points that are against it, we find the following favorable conditions embodied in the method.

1. The student has an opportunity to see a shop arranged for commercial production. During noon hours and, perhaps, at other times when not engaged, he may go about, ask questions, and observe for himself, thus gathering much valuable information.
2. The student has an opportunity to see modern tools installed and running in an efficient manner, and observe the operation of all classes of shop devices.
3. He gets used to factory routine.
4. He learns his place as a factor in the productive plan, and finishes his college course with a balanced estimate of his knowledge and usefulness.
5. He develops dexterity.

The unfavorable points, as the writer sees them, are as follows:

1. The student does not obtain a full understanding of the possibilities and the wide application of any one tool.
2. The ability to discriminate between methods of production, and their bearing upon economy, is not developed.
3. The underlying reasons for using jigs and fixtures and similar labor-saving devices are not made thoroughly clear.
4. There is a lack of general familiarity with elementary shop processes with which the engineer must necessarily come in contact.
5. The student cannot be placed to advantage in the various shops by the college authorities who are responsible for his training.
6. His executive capacities are not developed.
7. Necessary branches of the work are dropped from the course at will.
8. The trend is toward training a mechanic for the shop rather than an engineer.
9. There is insufficient supervision of the shop work by the college authorities, or else the supervision is ineffective.
10. A large number of students do not get the proper training and the opportunities which may be available are for a few.
11. The feature of alternating between shop and school (the Cincinnati system being based upon the plan of the student working one week in the shop and then the next week in the college, and so on) is detrimental to the student's work in both branches, because of the frequent extended interruptions, first in one department and then in the other.

The Trade Course

The previous discussion has dealt with the engineering work only, no thought having been given to the training of mechanics, as the method of teaching for the two classes should be entirely different. Boys learning a trade have four hours a week off to go to school, and are paid apprentice wages for this time. In the apprentice school the problems given are related to the shop. The writer did not have an opportunity to see a class in session, but talked with some of the boys, and apparently this work consists of a series of shop talks with related problems. The subject matter of these shop talks appears to be good, though limited in its scope. They are delivered by persons who know their business, which by the way, is a very important feature. The apprentice classes meet in a separate school building devoted to this work alone. This school feature, however, is the only feature which is in any way different from the apprentice course available almost anywhere in the country to a boy who enters a machine shop.

One must not regard shop talks and the solution of problems as the whole of trade teaching. They are important and necessary adjuncts, but the real teaching of the trade is done on the shop floor by a man who makes it his business to see that the apprentice understands what he is doing; at the same time he is given such a range of experience that he may enter any shop as an all-around man. This involves the ability to operate all the principal machine tools, as well as familiarity with floor work; as principal machine tools are classed the lathe, planer, shaper, slotter, milling machine, boring mill, and grinding machine.

Now it depends on the position which one takes relative to trade teaching, whether the manufacturer is morally responsible for teaching a trade such as outlined above or not. If no claim is made to public attention or funds, any manufacturer may give any kind of training that a boy is willing to accept, or may be compelled by force of circumstances to accept, and there is no fault to find. The manufacturer has a right to make the apprenticeship he offers meet his own requirements for the benefit of his plant, and take care that the working personnel may not become depleted. This is what the men in charge of the shops in Cincinnati claimed to be doing and nothing more. No person in authority with whom the writer talked claimed to be training all-around men. "Three branches is all we give, at most," someone said, "and all the boys do not get these." One man in charge at one of the shops stated very clearly that there was no claim towards doing anything in this matter of trade training that is not done in almost every community, except that in the continuation school an effort was made to give the boy a proper view of his trade.

While thus the writer was not given any erroneous impression of the nature of the training afforded boys under the Cincinnati arrangement by those in charge of the shops, yet is it claimed by the educational authorities in presenting the cooperative plan of work in Cincinnati that the boy has an excellent chance to learn a trade, and this is the one point where the system is open to criticism—when it is claimed before the public that a course based on the needs of the apprentice is offered, and that his needs are the prime consideration. Persons connected with the school work in Cincinnati, however, have no control over the shop work and no assurance that the boy shall apply any of the matter taught at school in practice. In fact, the school work seems to be merely a scheme to keep the boy interested in what he is doing in the shop, in a vague way, rather than having direct application to his work. No one on the shop floor gives the apprentice any special attention. The instruction he gets is mere chance, and is not a certainty for every boy.

Therefore, in view of the fact that, at best, but a limited course is offered, and that even such a course is frequently curtailed, it hardly appears that the cooperative plan is a good way to teach a trade, nor even a desirable way in view of the fact that there are better ways open at a low cost to any community. This way is the trade school pure and simple. Worcester, Bridgeport, and New Britain, as well as some other communities have tried this method and seem to be satisfied with it. To say that such a school is too expensive is to admit that one does not understand the operation of a plant on a business basis, because all the trades taught at a school can be made to contribute to its support in the making of its own equipment.

This article should not appear without an acknowledgment of the courtesies extended the writer at the various plants, and an appreciation of the frank and open way in which each of those in authority at these plants answered all questions and assisted in the obtaining of the required information.

* * *

When steel balls are used for burnishing small metal articles by tumbling, it is important that a liberal amount of steel balls be used. There is a strong tendency, particularly among the smaller manufacturers, to attempt to economize on the balls and use too few. The result is, according to the *Brass World*, that not only is it difficult to obtain a good burnished surface on the goods in a reasonable time, but sometimes the appearance of the articles is such that the manufacturer will condemn the ball burnishing process. If too small a quantity of balls is used, they do not come in contact with the surface of the work being burnished as often as is necessary, and hence the process is slower than it would otherwise be. Also, if a small quantity of balls is used, the surfaces of the articles being burnished come in contact with one another instead of with the balls, and abrasion takes place instead of burnishing. In establishments doing some excellent work by the use of steel balls it is customary to use about twice the quantity of steel balls as compared with the quantity of the work in the barrel.

* * *

When the New York, New Haven & Hartford railroad shall have completed the electrification of its lines all the way to New Haven, as recently decided upon, it will have a mileage of about 150 miles under electric operation, or a trackage of about 600 miles. It is expected that these lines will be electrified before the end of 1913. This electrification marks the greatest undertaking along these lines as yet definitely proposed.

IMPROVED DESIGN OF HYDRAULIC ACCUMULATOR

By ALEX. W. BEGGS*

In the December number of MACHINERY an illustrated description on designing a hydraulic accumulator appeared. The writer has no fault to find with this article, or the calculations as given for the design presented, but he takes exception to the design or type itself. The design shown is considered out of date, being what one might call "upside down." Furthermore, the author of the article states that it is better to make the plunger small in diameter and the stroke long, thus saving in the number and size of cast-iron weights required. The latter statement is, of course, correct, but it makes a more costly machine to build. Castings 23 feet long are difficult to make in the foundry and to handle in the machine shop, and few shops have lathes that will take castings of that length. In addition, there is the guide frame to build and to fasten to the building, and the overhead room required. It is also troublesome for the man who has to crawl in under the accumulator to pack the gland on the plunger.

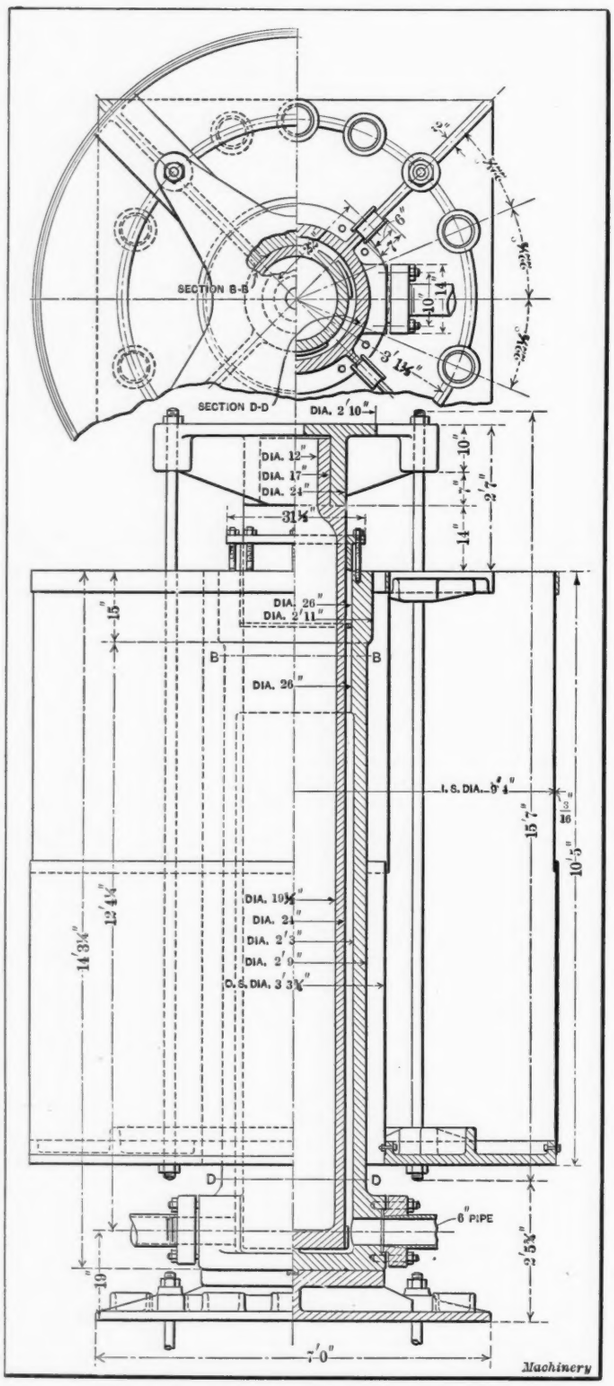

Fig. 1. Improved Design of Hydraulic Accumulator

If it is necessary to save on the cast-iron weights, a tank can be used which can be filled with any kind of cheap scrap. The accompanying illustration shows a 24-inch accumulator for 600 pounds pressure, of which several have been built. It is self-contained, and as the packing of the gland is at the top, it can be easily reached. It is the practice in some plants employing hydraulic power, to use about 600 pounds pressure for general work. If a higher pressure is required an intensifier is used.

All the principal points of the design are indicated in the illustration, and it is not necessary to elaborate on them. One point in the design may, however, be worth while calling attention to. As will be seen in the engraving Fig. 2, the plunger is provided with four lugs, 9 inches wide, on the lower end. Four similar lugs are also provided on the inside of the upper end of the cylinder. If the plunger is placed in the cylinder and then given one-eighth of a turn, this will bring the lugs exactly in line with each other, and when the plunger is extended to its full stroke, the lugs will come in contact with each other and prevent further movement of the plunger. The plunger is prevented from turning back by a 1½-inch bolt at the upper end, which passes through both the yoke and plunger. The yoke is prevented from turning by the flanged guide wheels on the bottom of the tank.

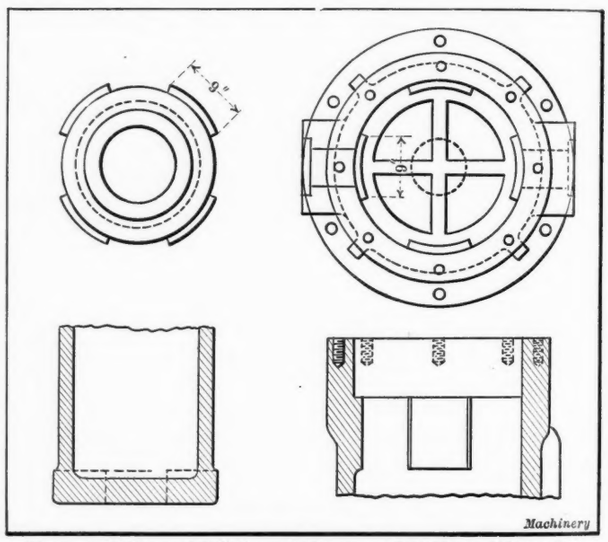

Fig. 2. End Views of Cylinder and Plunger, and Sections of Upper End of Cylinder and Lower End of Plunger, showing Safety Lugs

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BRITISH STANDARD DEFINITIONS OF YIELD POINT AND ELASTIC LIMIT

The Engineering Standards main committee has agreed upon the following definitions for yield point and elastic limit. The elastic limit is the point at which the extensions cease to be proportional to the loads. In a stress-strain diagram plotted to a large scale it is the point where the diagram ceases to be a straight line and becomes curved. The elastic limit can only be determined by the skillful use of very delicate instruments and by the measurement of the extensions for small successive increments of load. It is impossible to determine it in ordinary commercial testing.

The yield point is the point where the extension of the bar increases without increase of load. Practically, the yield point is the load per square inch at which a distinctly visible increase occurs in the distance between gage points on the test piece, observed by using dividers; or at which, when the load is increased at a moderately fast rate there is a distinct drop of the testing machine lever, or, in hydraulic machines, of the gage finger. A steel test piece at the yield point shows rapidly a large increase of extension, amounting to more than one two-hundredth of the gage length. The point is strongly marked in a stress-strain diagram.

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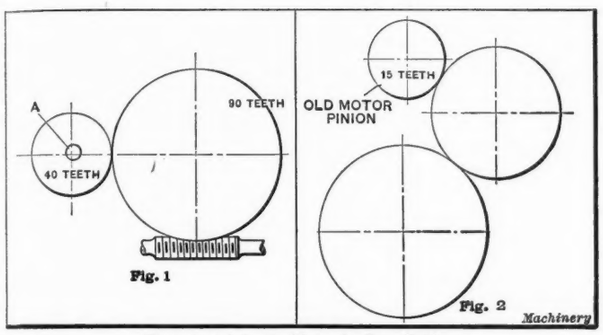
SHOP PROBLEMS INVOLVING GEAR AND PULLEY SPEEDS*

By J. H. CARVER†

In the following article are given a number of problems involving gear and pulley speeds. The problems are of a type likely to occur in ordinary shop practice, and their solutions are submitted with the hope that they will be of interest and value to those who may meet with similar instances, where the methods here given might be employed.

In the first place, assume that we have two gears with fixed center distance and a given ratio, which are to be replaced by two gears of a different ratio. Let R be this new ratio;



Figs. 1 and 2. Problems in Gear Ratios

and let the sum of the number of teeth in both the new and the old gears be $N + n = S$, where

N = the number of teeth in the large new gear,

n = the number of teeth in the small new gear.

R and S are known, and N and n are to be found. But, as $R = n \div N$, we have $NR = n$, or $NR - n = 0$. We have also $N + n = S$. Adding these two equations we have:

$$NR + N = S, \text{ or } N = \frac{S}{R+1} \qquad (1)$$

$$\text{From } R = n \div N, \text{ we have } n = NR. \qquad (2)$$

These formulas determine the number of teeth in the two new gears, which are of a different ratio but have the same center distance as the old gears.

As an example, assume that we have two gears on fixed studs, each having 60 teeth, and that these gears are to be replaced by two having a ratio of 4:11. Then, from the equations just given we have:

$$N = \frac{S}{R+1} = \frac{120}{(4 \div 11) + 1} = \frac{120 \times 11}{15} = 88 \text{ teeth.}$$

$$n = NR = 88 \times \frac{4}{11} = 32 \text{ teeth.}$$

In the arrangement of gearing shown in Fig. 1, shaft A is

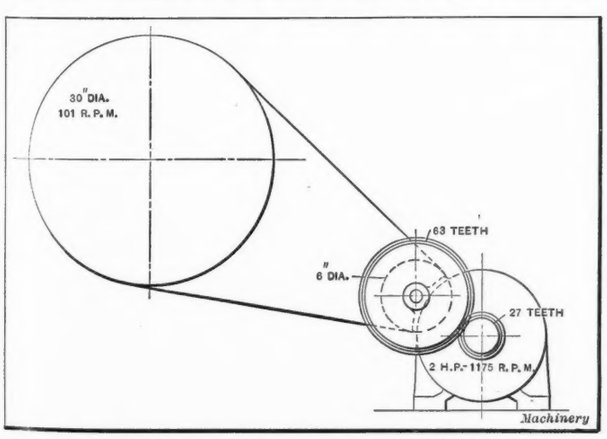


Fig. 3. Speed Reduction obtained by Gearing and Belting in Combination

turned by a worm- and spur-gear train. It is required to revolve shaft A thirty per cent faster by replacing the 40- and 90-tooth gears by other gears of proper ratio and suitable for the fixed center distance.

$$\text{Old gear ratio} = \frac{40}{90}. \quad \text{New gear ratio} = \frac{40}{90} + \left(\frac{30}{100} \times \frac{40}{90}\right) = \frac{52}{90}$$

$$\text{Hence, } N = \frac{S}{R+1} = \frac{130}{(52 \div 90) + 1} = 82.3,$$

or say 82 teeth, which is the nearest whole number. Further

$$n = NR = 82 \times \frac{52}{90} = 48, \text{ approximately.}$$

Hence, two gears of 82 and 48 teeth, respectively, making $S = 130$ teeth, as it should be, will give an increase of speed to shaft A of practically 30 per cent.

It is sometimes desired to change the size of the motor because of the increased duty of a motor-driven machine. For example, a 30-inch engine lathe is provided with a 2½ horsepower variable speed motor running at 700–1400 R.P.M., and it is desired to replace it with a 5 horsepower motor running at 500–1500 R.P.M. The speeds of the lathe spindle must cover at least the same range as before. The arrangement of the gears near the motor is shown in Fig. 2. The only change necessary would be in the motor pinion. The number of teeth N in this pinion is found from the proportion:

$$\frac{N}{15} = \frac{650}{500}, \text{ or } N = \frac{15 \times 650}{500} = 20 \text{ teeth, approximately.}$$

The value 650 is used in place of 700 because both slower and faster new speeds can thereby be provided for.

It often happens when belting from the motor to the pulley on a motor-driven machine, that the desired slow speed cannot be obtained by belting directly to the regular motor

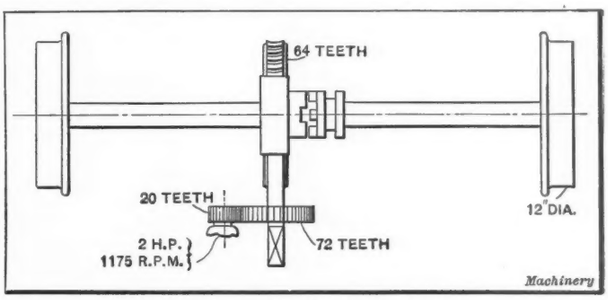


Fig. 4. A Simple Problem in Gear Ratios

pulley. In this case the motor may be geared as illustrated in Fig. 3. A bracket carrying a shaft is mounted on the motor frame. This shaft has a gear on one end meshing with a pinion on the motor shaft, and a driving pulley on the opposite end to which the pulley on the machine to be driven is belted.

A punch-press, for example, has a balance wheel 30 inches in diameter, as indicated in Fig. 3, and is driven by a two-horsepower constant-speed motor running at 1175 R.P.M. The required speed of the balance wheel is 100 revolutions. It will be found that by the arrangement shown a speed of

$$\frac{1175 \times 27 \times 6}{63 \times 30} = 100.7 \text{ R.P.M.}$$

will be obtained, which is near enough for practical requirements.

An inclined hydraulic press, whose back yoke is mounted on wheels and designed to be moved by an individual motor at a speed of 16 feet per minute, is arranged in the manner indicated in Fig. 4. A two-horsepower constant-speed motor is used, running at a speed of 1175 R.P.M. The wheels on which the yoke is mounted are 12 inches in diameter, or 3.14 feet in circumference. Hence, the number of revolutions necessary for a speed of 16 feet per minute equals $\frac{16}{3.14} = 5.1$ revolutions. Further, the speed of the worm $= 64 \times 5.1 = 326.4$ R.P.M. Assume that we choose a 20-tooth gear on the motor shaft. How many teeth should the gear on the worm-shaft, meshing with this 20-tooth gear, have? Denoting the

* For a treatise dealing more completely with the principles involved in the problems presented in the present article, see MACHINERY's Reference Books No. 18, "Shop Arithmetic for the Machinist," and No. 52, "Advanced Shop Arithmetic for the Machinist."

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number of teeth to be found by T, we find this number as follows:

$$T = \frac{20 \times 1175}{326.4} = 72 \text{ teeth.}$$

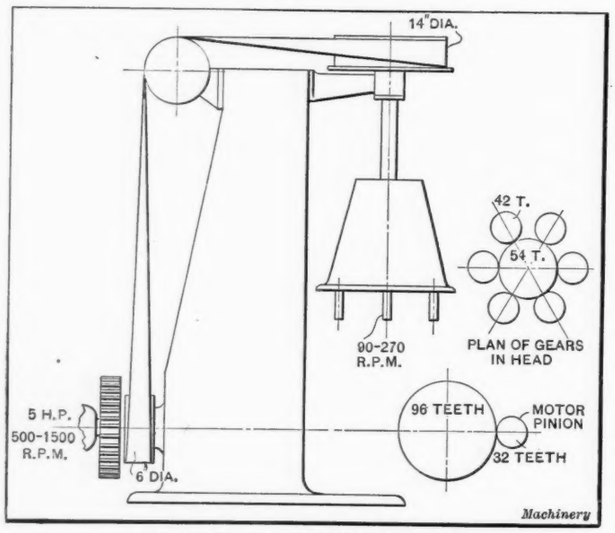


Fig. 5. Drive of a Six-spindle Drill Press

In Fig. 5 is shown a diagram of gears and pulleys used on a six-spindle multiple drill. A 32-tooth pinion on the motor meshes with a 96-tooth gear, as shown. A five-horsepower motor, 500–1500 R.P.M., was used. The drill speeds necessary were 90–270 R.P.M. The number of teeth in the motor pinion was found as follows:

$$\frac{96 \times 14 \times 42 \times 90}{6 \times 54 \times 500} = 32 \text{ teeth, approximately.}$$

A three-spindle sensitive drill was to be equipped with a ¾-horsepower variable speed motor, running at 600–1800 R.P.M. It has been found that ¼ horsepower per spindle is ample for driving sensitive drills. In the old belt-drive arrangement, the drive was to a 12-inch pulley, driving the cone-shaft at 420 R.P.M., as indicated in Fig. 6. The motor is belted to the same pulley, as shown. The diameter of the pulley on the motor is found as follows:

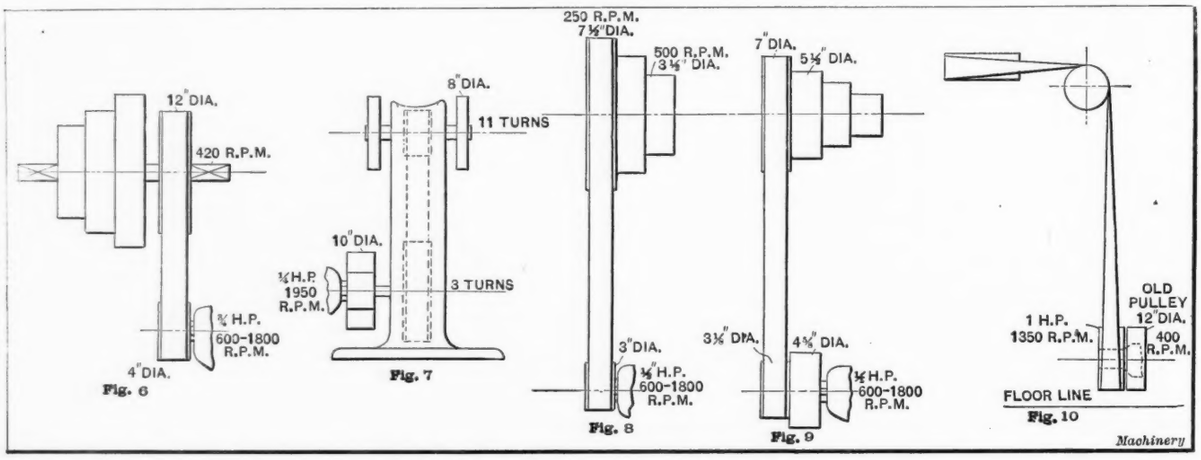
$$\frac{12 \times 200}{600} = 4 \text{ inches diameter.}$$

The value 200 is used instead of 420 in order to give a slower speed for the lowest motor speed than that obtainable by the belting arrangement. The average motor speed will then give the required speed to the cone shaft.

A grinder using an 8-inch emery wheel is to be driven as shown in Fig. 7, by a ¼-horsepower motor running at 1950 R.P.M. The emery wheel is run at 2100 R.P.M. The pulleys shown dotted are enclosed, and it is difficult to measure their diameters so as to determine the proper size for the motor pulley. By turning the emery wheel spindle, however, it can be found that eleven turns of the emery wheel correspond to three turns of the 10-inch pulley belted to the motor pulley. Hence, the speed of the 10-inch pulley equals $\frac{3 \times 2100}{11} = 573$ R.P.M., and the size of the required motor pulley will be $\frac{10 \times 573}{1950} = 3$ inches, approximately.

When changing the style of drive on a machine tool from belt to motor drive, it often happens that a cone pulley must be belted to the motor pulley. In the case of many lathes, profiling machines, drill presses, shapers, slotters, milling machines and special tools, the ratio of the speeds obtainable through the cone pulley may run from 3 to 1, according to whether the belt is on the smallest or largest step of the pulley. In such a case a 3 to 1 variable speed motor with the proper diameter of pulley to give the desired slow speed when belted to the large step of the cone will also give the corresponding high speed. As an example, assume that a turret lathe runs at 250 R.P.M. with the belt on the largest step, and at 500 R.P.M. with the belt on the smallest step, as indicated in Fig. 8. This lathe is to be belted directly from the motor pulley to the largest cone step. A 3-inch motor pulley gives a greater speed range than the old speeds, when using a ½-horsepower motor running at 600–1800 R.P.M.

In the case of higher ratios of machine cone pulleys, where the motors obtainable do not cover the desired speeds, a two-step motor pulley will meet the requirements. For example,



Figs. 6 to 10. Miscellaneous Examples of Belt Drives

a speed lathe, the cone of which together with the two-step cone of the motor is shown in Fig. 9, is driven by a ½-horsepower motor running at 600–1800 R.P.M. The lathe originally ran at 200–1500 R.P.M. With the motor pulley shown the speeds are 270–810 R.P.M. with the belt on the large step of the lathe pulley, and 500–1500 R.P.M. with the belt on the next smaller step.

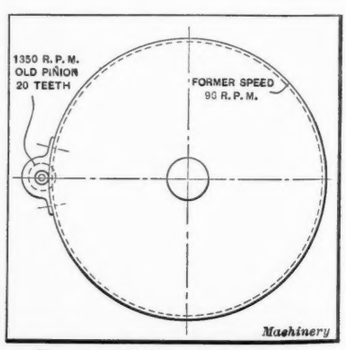


Fig. 11. A Problem in Gear Ratios

A drill press was belted in the manner shown in Fig. 10. The 12-inch tight and loose pulleys shown were to be removed and replaced by a motor with pulley. The pulleys ran at 400 R.P.M. The motor was 1 horsepower, running at 1350 R.P.M. The peripheral speeds of the 12-inch pulley and the required motor pulley must be the same, if the drill press speed is to remain unchanged. Therefore, when the speed is increased, the diameter will be proportionately decreased, and

hence, the diameter D of the required motor pulley will be found as follows:

$$\frac{D}{12}=\frac{400}{1350}, \text{ or } D=\frac{12\times 400}{1350}=3.55,$$

or, say, 3½ inches, which is near enough for all practical purposes.

Fig. 11 shows a diagrammatical view of a punch press arrangement, the balance wheel being driven by a ½-horsepower motor running at 1350 R.P.M. The motor pinion has 20 teeth meshing with teeth in the balance wheel. The wheel runs at 96 R.P.M. It is desired to change to a 2-horsepower motor running at 1175 R.P.M., and at the same time increase the speed of the balance wheel to 110 R.P.M. The balance wheel is enclosed, making it difficult to measure or count the number of its teeth. By the calculations in the following, the necessary number of teeth in the new motor pinion is determined without reference to the balance wheel. If N is the number of teeth required, then

$$\frac{N}{20}=\frac{1350}{1175}, \text{ or } N=23 \text{ teeth, approximately}$$

if 96 turns per minute, only, were required; but when 110 R.P.M. are required, we would have:

$$\frac{N}{23}=\frac{110}{96}, \text{ or } N=26 \text{ teeth.}$$

* * *

An electrically operated blueprinting machine, used for making the blueprints for the municipal departments of St. Louis, Mo., produced 15,900 blueprints last year. According to the *Engineering Record*, the cost per square foot, including labor, material, and depreciation of the machine, was 1.5 cent for blueprints, 3.4 cents for brown-prints, 5.4 cents for black-prints, and 6.4 cents for blue-cloth-prints.

AUTOMATIC DIE-CASTING MACHINES*

By E. F. LAKE†

Nearly all die-casting machines in use at the present time are operated by hand, that is, a number of levers are pulled back and forth to perform the different operations of closing the mold, moving the plunger to force the metal into the mold, cutting off the sprue, opening the mold, and ejecting the castings. Nearly all of these machines require two men to operate them, and in some cases it requires five men to operate two machines. With these hand-operated machines a large quantity of castings can be manufactured in a day, and many have not considered it necessary to design and build more expensive machines. Some manufacturers, however, have built completely automatic machines for their own use, in order to save the labor cost of the hand-operated machines.

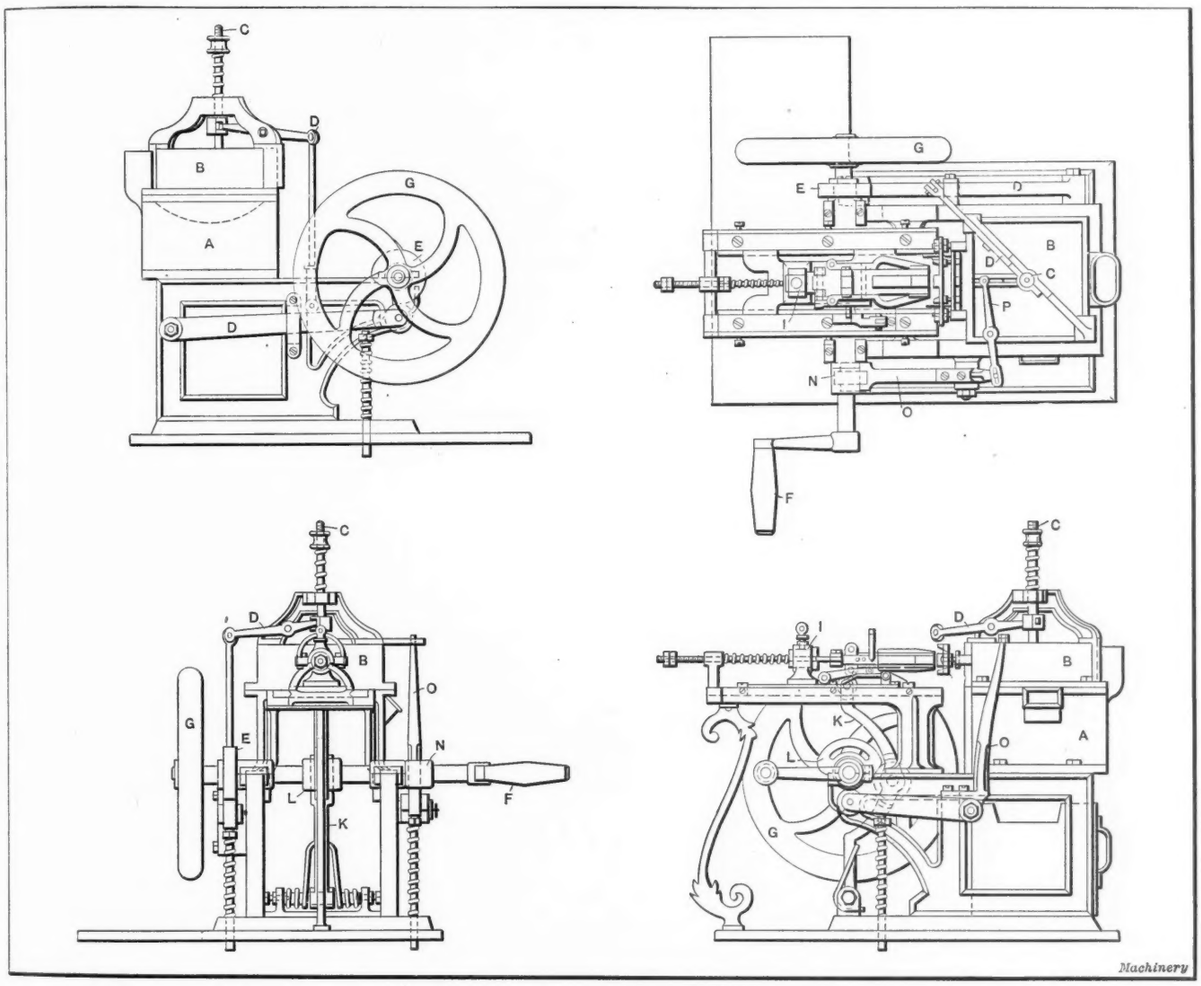


Fig. 1. First Automatic Die-casting Machine

These automatic machines are very successful, and are producing die-castings at a very low cost.

Automatic machines for casting type have been in use for more than sixty years, and these are, in reality, die-casting machines, although only used for the particular purpose of manufacturing type. Like all other die-casting machines, the automatics were devised from ideas and principles adopted in the type-casting machines, and are, in fact, largely improvements of these. The first attempt at applying such machines to the manufacture of castings, other than type, is shown in Fig. 1. This machine was patented by M. Dimock in 1875 for the manufacture of sewing machine bobbins. By turning crank F, all movements were produced that were necessary for the casting of a bobbin and throwing it out of the machine. By putting a pulley in place of the crank, it could be belt-driven and thus made completely automatic. In this machine,

* See MACHINERY, July, 1911, engineering edition, "The Design of Die-casting Machines—Alloys for Pressure Castings," and also the previous articles there referred to.

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A is the furnace and *B* the melting pot located over the furnace, in which the metal is melted and held, ready for casting; *C* is the upper end of the pump or plunger that forces the metal into the mold. This plunger is raised and lowered by levers *D*, which in turn are moved by cam *E* located on the driving shaft, which passes through the machine from crank *F* to the flywheel *G*. The mold and the apparatus for opening and closing it and ejecting the casting are located on a

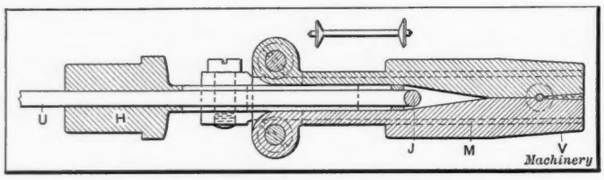


Fig. 2. Die-mold and the Bobbin cast

framework just above this shaft. The die-mold receives its metal from a nozzle in the side of the melting pot.

The cross-section of the die-mold, with shank *H* on which it is pivoted, is shown enlarged in Fig. 2; the bobbin which is cast in it is shown above the mold. Shank *H* fits into cross-head *I*, and is, by means of this cross-head, pulled back from the spout so that it can be opened. The two halves of mold *M* are opened like an alligator's jaw by turning bar *J*, which is long enough for this purpose and is located on the end of shaft *U* that passes through shank *H* and carriage *I*. The cast bobbin is then thrown out and the mold closed, ready for another casting. The cross-head and mold are moved back and forth by lever *K*, one end of which is pivoted to the frame at the bottom of the machine, while the other end works in a slot in the cross-head. Lever *K* is operated by cam *L* which is located on the center of the main shaft. When mold *M* is moved up to the nozzle of the machine, the tapered end at *V* enters a socket, thus holding the mold firmly closed. As soon as the mold assumes this position, a cam located on the main shaft at *N* operates hinged lever *O*, and this, in turn, moves lever *P*, which opens a valve that allows the molten metal to be injected into the die-mold. This valve operates in practically the same manner as valve *T* in Fig. 3 and valve *L* in Fig. 5, to be described later. In the meantime, plunger *C* has been raised to the top and as soon as the metal cut-off valve opens, the plunger is forced down and fills the mold with metal.

While this machine was simple in design, it worked fairly well, and many castings were made with it. The springs which gave the levers their return motion, however, were not positive enough, and on later machines cams were added for this work. A sprue cutter, such as is now used, was not provided, and hence the sprue had to be broken off from each casting. These were about the only faults that could be found, and the principles here adopted were developed to a point that enabled automatic die-casting machines to cast pieces very intricate in shape. Movements were devised for pulling out pins, located in the die-molds, as well as other loose pieces that might form any size or shape of hole in the casting.

In 1902, Mr. C. H. Veeder patented the machine shown in Fig. 3. On this he was granted patents on nineteen combinations claims, but it will be seen that, although the machine is greatly improved in its design, the basic principles on which it operates are practically the same as those of the machine patented in 1875. The furnace is located at *A*, the melting pot at *B*, and the upper end of the plunger at *C*, as in the former machine. Lever *D* is operated by cam *E* and moves rod *Q* and lever *R*, which latter causes plunger *S* to travel up and down and squirt the molten metal into the die-mold. Another cam moves pivoted lever *O*, which is connected with the valve rod, and opens and closes valve *T* in identically the same manner as did the earlier machine; in fact, the shape of lever *O* is almost the same. This, however, is a design that has been successfully used for years on type-casting machines and is difficult to improve upon.

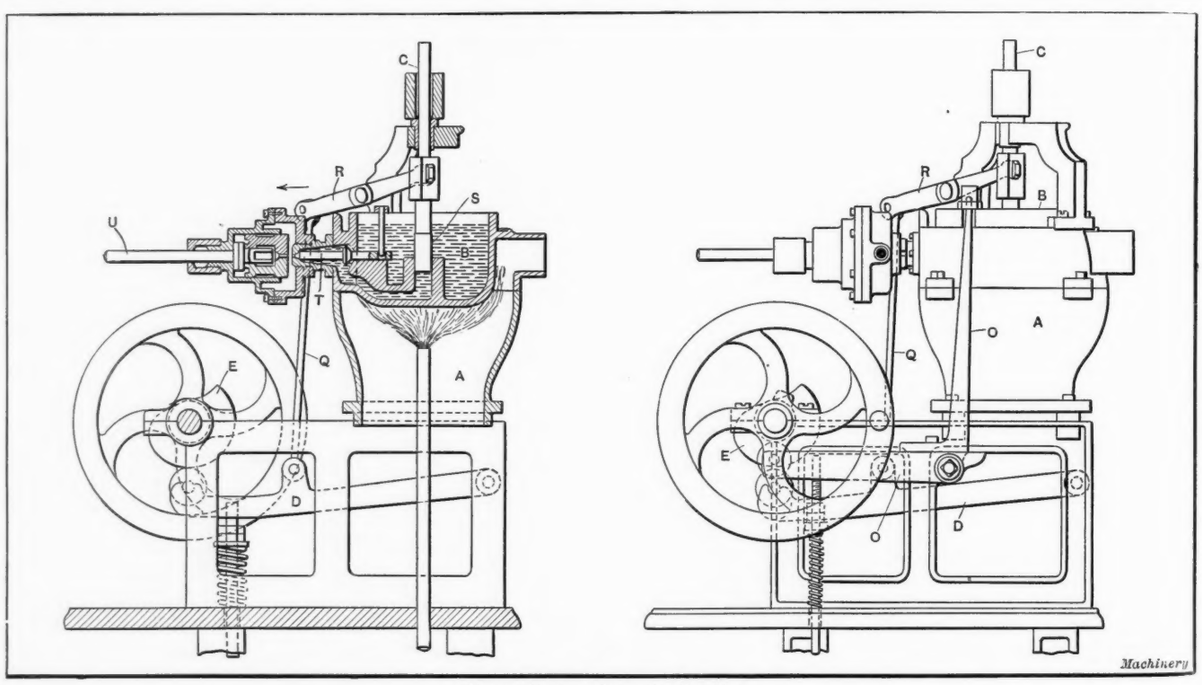


Fig. 3. Modern Die-casting Machine

The manner of parting the mold to remove the casting is altogether different. Instead of opening it like an alligator's jaw, as in the earlier type of machine, a part of the mold is moved back, away from the machine, and the casting is thus allowed to fall out. The mechanism that opens and closes the mold is not shown in Fig. 3, but it is done with a very similar supporting frame and cross-head to that which draws the mold away from the nozzle in the Dimock machine in Fig. 1; but, instead of using rod *U* to turn bar *J* and thus open the mold, as in the Dimock machine, rod *U* is used to form a core in the casting and after the casting has been made, rod *U* is pulled back to free the casting from the mold. This machine has been used for several years, but has also been improved upon. It has been made entirely automatic by putting a pulley in place of the crank wheel.

While in most automatic machines cams have been used to control nearly all of the movements, in others springs and gears have been used in combination with cams. Such a machine is shown in Fig. 4. In this a cam *E* is used to control the motion of the pump plunger and a large spring is used to hold the lever against this cam. The mold is moved

up to the spout and away from it by a crank on the end of the shaft that holds the cam. This shaft is driven by a gear *N* that meshes with a pinion *L* driven by a worm-wheel *K* and worm *J;* the worm, in turn, is driven by a pulley *F* and belt. A stationary cam is used to control the motion of a knife which cuts off the sprues and a brush that brushes off the knife. With the exception of the spring for holding the lever that operates the plunger against the cam, this machine works successfully. A spring in this location is liable to fail, owing to the plunger's sticking in the cylinder, due to dross in the molten metal; no metal would then be forced into the mold.

This machine was especially designed for casting electric storage battery grids, but can well be used for making many shapes of castings for machine parts. These grids are thin strips of metal, crossing each other at right angles, the strips being joined together at each intersection; they thus contain a number of square openings, and resemble wire netting, except that the strips are not round. As in the other die-casting machines, *A* is the furnace, *B* the melting pot over the furnace, *C* the plunger rod, and *D* the lever that operates the plunger. A roller attached to lever *D* rides on cam *E*, to guide the up and down motion of plunger *G;* spring *I* holds lever *D* against cam *E*. It would doubtless be better to use another cam to perform the work of this spring and thus make the upward motion of the plunger as positive as is the downward motion. Cam *E* is so shaped and timed in its motion as to cause the plunger *G* to move down only when the mold is closed tightly against the nozzle and ready to receive the metal. To reduce the air pressure in the mold against the plunger's action and insure that all parts are filled with the incoming metal, an air pipe *Y*, with pump, is often connected to the mold. This automatically pumps out the air and creates a vacuum in the cavity of the mold that shapes the casting, just before the molten metal is injected into it by the plunger.

The mold is operated by a mechanism that is as simple, positive and handy as that of any die-casting machine made. Mold *M* is located on rocker arm *H*, which is connected by rod *P* and spring *Q* to crank *R*. Thus, while cam *E* is controlling the operation of plunger *G*, crank *R* is controlling the movements of the mold. Mold *M* is thus brought up to the nozzle and held there while plunger *G* descends and squirts the metal into it. Plunger *G* is then raised for another stroke, while mold *M* is rocking back away from the nozzle. For the grid casting made in this machine many gates are used, and while the rocker is carrying the mold back to the end of its stroke, knife *S* travels across the face of the mold and cuts off the sprues. A brush then travels across the face of knife *S* and brushes off any chips that may have accumulated. These motions are controlled by cam *U*, which is bolted to the side of the frame.

On many kinds of castings for machines or instruments, the shape is such that this knife and brush could not be used for the sprue cutter, but it is easy to take off this mechanism and attach others that would perform the necessary operations, and which might be even simpler in design. The distance through which rocker arm *H* travels can be

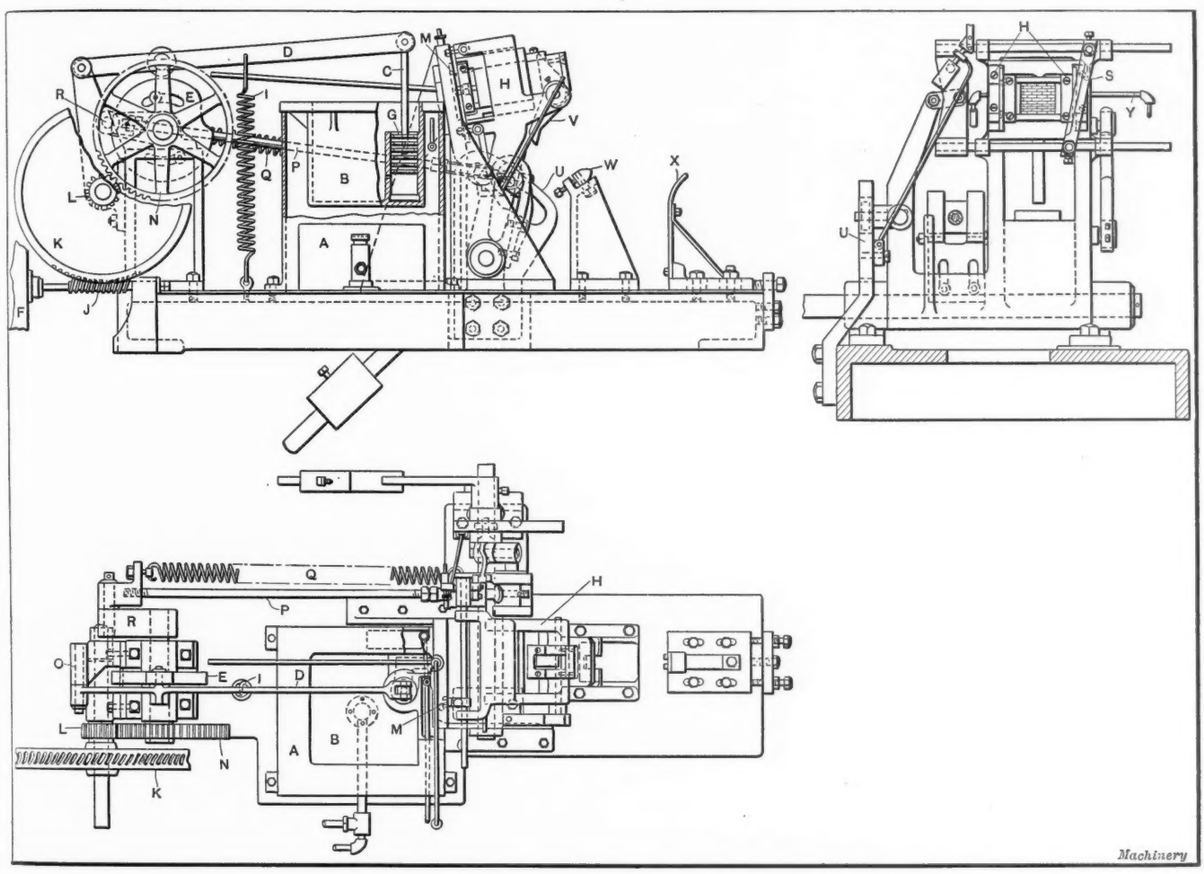


Fig. 4. Another Modern Type of Automatic Die-casting Machine

adjusted by shortening or lengthening rod *P* by the nuts provided. The mold can thus always be kept tightly against the nozzle, and also go back far enough to eject any casting. When rocker arm *H* reaches the end of its backward stroke, arm *V* strikes block *W* and this operates the mechanism that ejects the casting from the mold. To insure no jar, flat spring *X* is provided for rocker arm *H* to strike against.

One of the most complete automatic die-casting machines built is shown in Fig. 5. This machine was patented by Mr. C. H. Veeder and is a vast improvement over the machine shown in Fig. 3. It is supplied with two melting pots and is completely automatic. All that the attendant has to do is to keep the secondary melting pot filled with metal and carry away the finished castings. With each casting that is made, the metal lowers in the melting pot and the secondary melting pot is used for the purpose of keeping the primary melting pot filled. In this machine the air is exhausted from the mold with an air pump before forcing the metal into it, thus insuring the filling of every crevice. The machine differs from nearly all other types in that it has provision for a

powerful, positive pressure for forcing the metal into the mold, in addition to the vacuum. Thus, the formation of gas bubbles or air pockets in the cavity that forms the castings is overcome and deformed castings are not produced. The percentage of bad castings has, therefore, been reduced to a minimum.

In this machine also, *A* is the furnace; *B* the melting pots; *C* the plunger; *D* the lever that moves the plunger up and down; *E* the cam that causes the movements of this lever; *F* the pulley that drives the machine; *H* the carriage that holds and operates the mold; and *M* the mold.

A single shaft *J*, driven by pulley *F*, controls all the movements. Cams are located on the central portion of this shaft and cranks on the two ends to give the machine all of its movements. No gears are used. A double-action valve is used to control the injection of the metal into the mold, and to cut off the sprue. This valve is shown at *L*. Before plunger *C* starts moving downward, arm *N* is moved away from valve *L* and the flow of metal due to the downward motion of plunger *C* causes valve *L* to move to the left and close the opening between the passage in which this valve is located and the melting pot. Thus, all of the pressure exerted by the plunger is used to force the molten metal from this valve chamber into the mold. When the die-mold has been filled, arm *N* pushes against valve *L* and causes it to close up the nozzle opening through which the metal flows into the die-mold, and, at the same time, valve *L* cuts off the sprue of the casting. Arm *N* is moved by lever *O*, which, in turn, derives its motion from cam *P*.

Carriage *H*, which holds the mold and controls its movements, is operated by a series of levers that are moved by two cams. Lever *Q*, with its connecting levers is moved by cam *R*, and this pulls carriage *H* to the right to open the die-mold as shown in the lower left-hand view of Fig. 5. By the action of cam *R*, lever *Q* afterwards moves carriage *H* to the left, thus closing the mold and holding it tightly against the nozzle while it is being filled with the casting metal. Spring *I* holds the roller of lever *Q* against cam *R*. This is a weak point of the machine, as the pressure that forces the molten metal into the mold is exerted against this spring, unless a locking device is attached to the mold, and this requires additional mechanism. Another cam could more easily be used to close the mold and hold it against the pressure of plunger *C*. While the mold is opening, bar *S* is moving to the left through carriage *H* to eject the casting from the mold. The movement of bar *S* is controlled by a series of levers moved by cam *T*. While the mold is closed, vacuum tanks *U* are automatically connected with it and draw out all of the air. A vacuum is constantly maintained in these tanks by an air pump.

With all of these movements properly timed, die castings are made as fast as the metal will solidify, and can be ejected from the mold without deforming the castings. Most die-casting machines do not apply as much pressure to the plunger, but depend on the suction created by the vacuum to draw the metal into the mold. This does not produce castings with as fine and dense a grain as when a high pressure is applied, and they are more liable to have porous and spongy places. The high pressure, combined with the vacuum in the mold, also makes the casting correspond exactly to the contour of the cavity cut in the mold. One die-mold can be taken out and another, for a different casting, inserted in its place with very little labor. Thus the machine can be made to operate on several kinds of castings in a day's run.

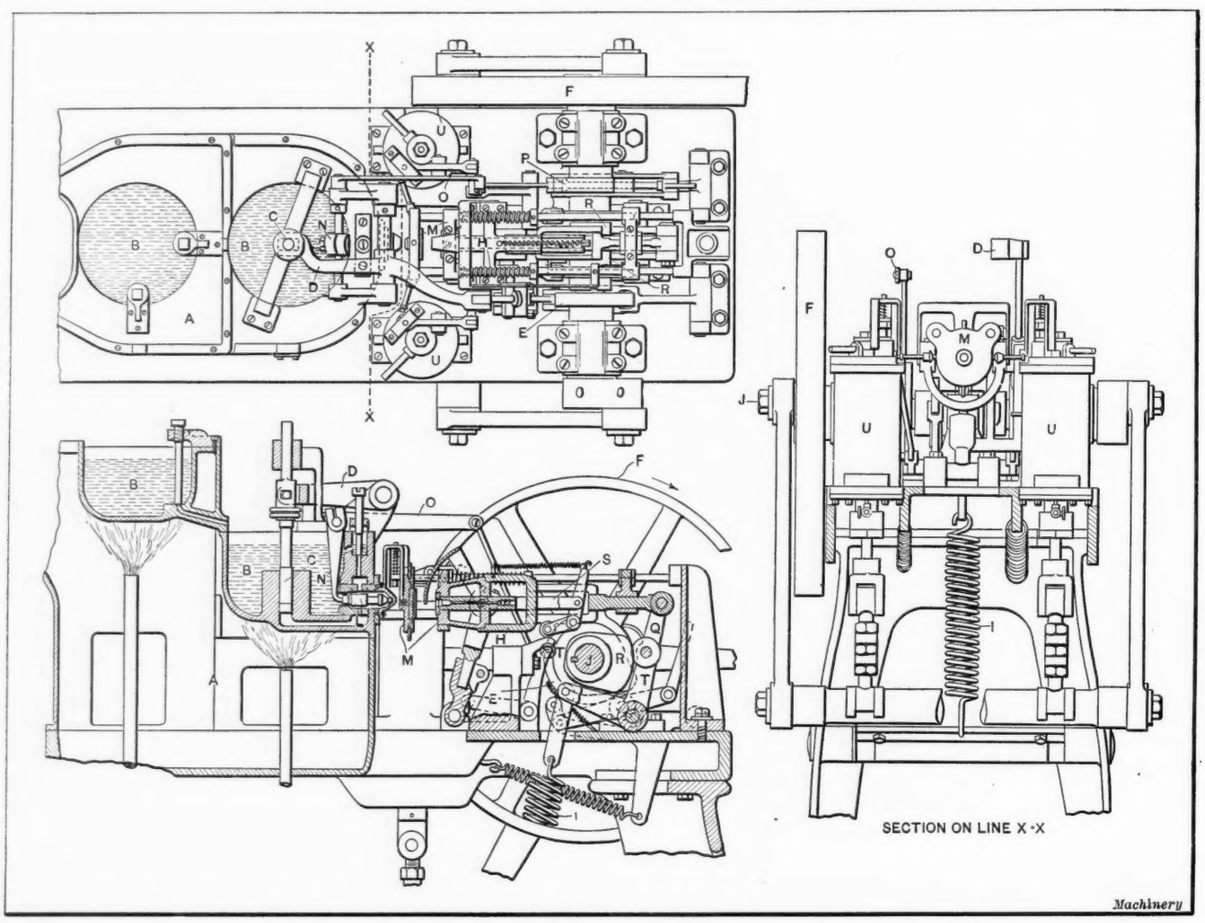


Fig. 5. The Latest Type of Automatic Die-casting Machine

These and other reasons make it one of the most economical machines built, as the cost of the castings has been reduced to little more than the cost of the metals for making the alloys, the gas that keeps the metal molten, interest on original investment, and the expense necessary to keep the machine in repair. Automatic type-casting machines cast one type at a time, at the rate of 240 per minute. This speed is largely due to the fact that cold water is forced through a water-jacket that surrounds the type cavity in the mold; as many as 240 per hour would be a high figure for die-castings for machine or instrument parts, as these are nearly always

more intricate in design and have a larger volume of metal to be cooled. Many times, however, more than one casting can be made in a mold. When the mold is water-jacketed, and the machine completely automatic, the output of perfect castings will be many times that of hand-operated machines, and at a very low labor cost.

The formation of coarse crystals is an inherent trait of all metals when they are slowly cooled from the liquid state. This coarse crystallization is more pronounced in some metals than in others, and the alloys from which die-castings are made are composed of the metals that form the coarsest crystals, when so cooled. The most notable example of this crystalline formation is antimony, while zinc is another metal that has a very flaky crystalline structure. This formation of coarse crystals can be overcome to a large extent if the metals are chilled and suddenly solidified from the molten state, when casting them into shape. This is done in the machine shown in Fig. 5 by circulating a stream of cold water through a water jacket formed around the cavity in the mold that forms the casting. While the vacuum created in the cavity of the mold and the pressure used to force the metal in have a tendency to reduce the coarse grain and crystallization, the rapid cooling and solidification that is caused by the current of cold water still further aids in refining the grain.

The action is similar to that which takes place when hardening steel. In this case, the grain is refined by heating cold metal to the desired temperature, and the fine grain is retained by instantly quenching in a liquid, and thus suddenly cooling the metal. If it were allowed to cool slowly, the grain crystals would return to the coarse size of the unheated steel; or if heated to too high a temperature, a coarse grain would be formed that could only be refined by the pressure or hammering applied during forging operations. In the die-casting alloys, this fine grain is produced by melting, and the quicker it can be cooled down from the molten state, the finer will be the grain of the metal in the castings. It is not a difficult matter to surround the casting cavity in all die-molds with a water-jacket. This, of course, will not only give the metal a more dense, homogeneous grain, but will also solidify the castings much more quickly and enable many more castings to be made per hour than can be made in a machine where the mold is not water-jacketed.

* * *

The manufacture of tungsten lamps has been a difficult and expensive matter because of the characteristics of tungsten. Up to a few months ago it was impossible to draw tungsten into wire as the common ductile metals are drawn, but it had to be squirted while in the so-called "colloidal" state to form the required filaments. The other elements mixed with the powdered tungsten had to be driven off by heat, thus leaving a very brittle wire, exceedingly difficult to mount in the lamp and easily broken by shock. Now, thanks to improved methods of treatment, it is possible to draw the pure metal into wire of great tenuity, diameters of 0.003 inch or less being readily produced. The metal is drawn through diamond dies into lengths of 600 or 700 feet and can be wound on spools without danger of breakage. The success of the research has made the tungsten lamp as practicable as the old carbon filament lamp which it is rapidly displacing because of its much greater efficiency.

* * *

A reader suggests that the boss who refuses to help a man acquire knowledge of those things in which he is weak for fear that he might get the boss's job some day, is not up-to-date. The modern foreman strives to surround himself with intelligent men, realizing that the higher the grade of average intelligence of men, the better will *he* stand with his employers. The intelligent foreman should cooperate in the training of an understudy who will be able at a moment's notice to take charge of his department. The late R. T. Crane of Crane & Co., absolutely required that every man occupying a responsible position have an alternate who knew all his duties and how to execute them. Did this mean that the foremen were likely to lose their jobs at any moment's notice? No, on the other hand the tenure of position was much more secure there than in the common run of factories.

THE EVOLUTION AND PRESENT DEVELOPMENT OF THE TURBINE-PUMP*†

At the present time the use of the turbine-pump has become so extended that it is difficult to find services to which it cannot be advantageously applied. It will no doubt, therefore, be a matter of interest to trace the evolution and development of machines of this design, and this, perhaps, cannot be better done than by considering in particular one type only. As a description of the commercial application of the steam-turbine is a history of the Parsons machine, so that of the turbine-pump can be adequately portrayed by an account of the evolution of the Osborne Reynolds pump.

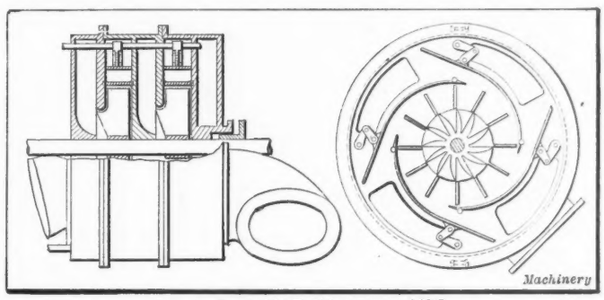


Fig. 1. Reynolds Turbine-pump, 1875

Centrifugal pumps were in the past accepted by engineers as suitable appliances for easily and cheaply (as to first cost) raising water to low heads. It was not realized that they were capable of dealing with any but low heads; in fact, this view became a canon of ordinary engineering practice, creating a tradition which took many years to remove. It is singular that, though the water-turbine with its guide-vanes was a matter of common knowledge at the time, no attempt appears to have been made to reverse its action with the prospect of obtaining a similar high efficiency and increase of head, for the purpose of raising water. There was, however, one exception in the invention of Prof. Osborne Reynolds'. It is the object of the present article to trace and discuss the development of this invention.

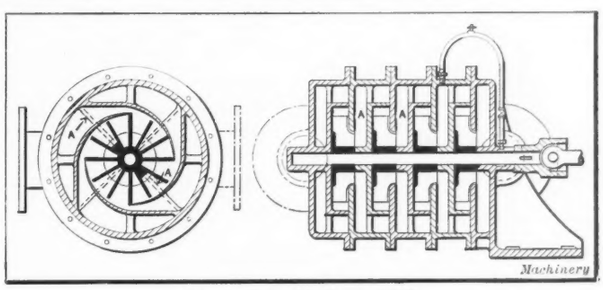


Fig. 2. Reynolds Pump, 1887

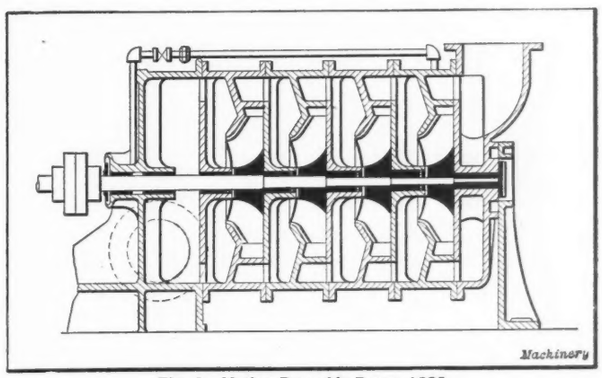


Fig. 3. Mather-Reynolds Pump, 1895

* Abstract of paper by Dr. Edward Hopkinson and Mr. Alan E. L. Chorlton, of Manchester, England, read before the Institution of Mechanical Engineers, January 19, 1912.

† For additional information on this and kindred subjects, see the following articles previously published in MACHINERY: "Self-contained Turbine Pumping Engine," April, 1910; "Turbine Pump Motor Drive," and "Electric Drive of Turbine Pumps," December, 1909, engineering edition; "Centrifugal Pumps," June, 1909, engineering edition; "Centrifugal Pumps," February, 1909, engineering edition. See also the note published in connection with the last mentioned of these articles.

In 1875 Prof. Osborne Reynolds invented a turbine-pump of the series type, fitted with guide-vanes, as shown in Fig. 1. Comparison of this figure with illustrations following show how the essential features of his original proposition have been adopted in subsequent practice. In this pump the impeller delivered its water to tangent guide-vanes, as shown, and the similarity to an inward-flow turbine of the Thomson type is noticeable, for, as in that machine, the mouths of the

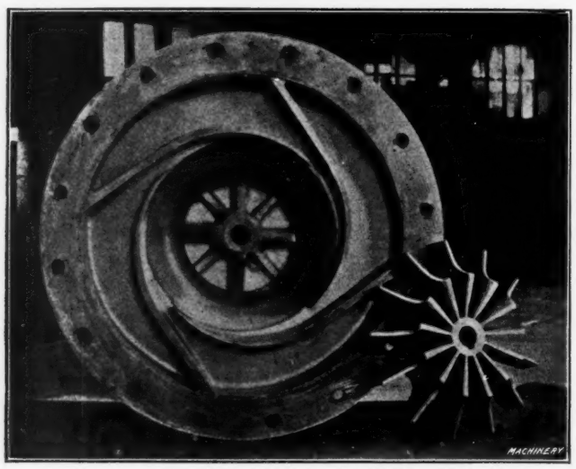


Fig. 4. Impeller and Guide-passages of Mather-Reynolds Pump

guide-channels could be regulated to raise the efficiency of the pump for smaller outputs, a device however seldom adopted in later practice.

Nothing of any commercial value appears to have been done with the invention for many years; in fact, the first pump of which records and tests are available was constructed in 1887 by the firm of Mather & Platt for the engineering laboratory of the Owens College, Manchester. This pump, shown in cross and longitudinal section in Fig. 2, had four impellers in series and gave at 1500 revolutions per minute a total head of 148 feet or 37 feet per chamber. The average efficiency recorded in the tests made by Prof. Reynolds was 58.5 per cent, a high result, in proportion to its small size, for a pump made twenty-five years ago. The readings were taken from a dynamometer fixed between the pump and the belt-pulley, and, as no method of damping the indicating finger seems to have been employed, they may be liable to some error. Thus the maximum efficiency obtained, *viz.*, 70 per cent, appears open to some doubt. The guide-vanes, after leaving the wheel in a curve, reached the inner periphery of the outer shell of the chamber at an angle. The water having had its velocity of whirl converted into pressure-head in these passages, had then to pass sideways at right angles into radial-return passages formed in the back portion of the chamber and marked *A* in Fig. 2. In these passages the water was guided and prevented from rotating by radial vanes. The water on reaching the center passed into the eye of the second impeller, and so on until it was finally delivered at the pump outlet at the head pressure required. It will be observed that the impeller was of the open type with radial vanes.

The tests of Prof. Reynolds proved the capability of the pump to perform many duties, previously thought impossible by centrifugal pumps, and in 1893 the firm of Mather & Platt took up its commercial manufacture. The mechanical construction of a standard Mather-Reynolds pump as built in 1895 is illustrated in longitudinal section in Fig. 3. The impeller

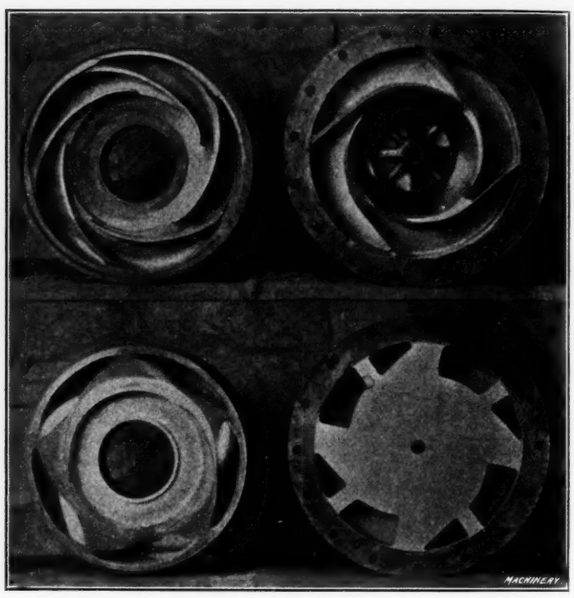


Fig. 5. Comparison between Guide-vanes in Pump of 1895 and Modern Pump

and guide-passages are also shown in Fig. 4. The pump consists of four chambers working in series. At one end, these are secured by bolts against the circular flange of a frame carrying the driving pulley or shaft coupling, this having the suction branch and entrance to the first chamber cast with it. At the other end the delivery chamber forms the final cover, and has the delivery pipe cast on the upper part connecting to the annular space into which the last set of guide-passages deliver, and at this end a suitable stay is attached to support the pump from the floor. The chambers are secured to each other by bolts through external flanges, each chamber being recessed and spigoted so as to preserve the correct alignment of the whole. This forms an inexpensive design, and permits of accurate manufacture. It allows of

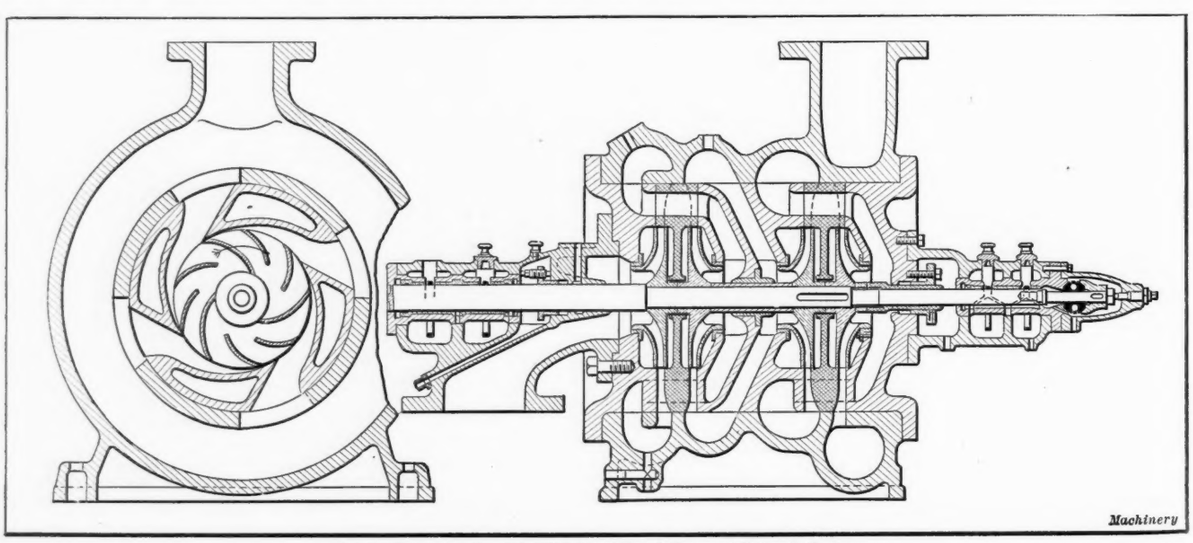


Fig. 6. Four-chamber High-lift Centrifugal Pump of Sulzer's Design

chambers being added or subtracted for higher or lower heads. Each chamber is distinct in itself, and has on one side the guide-vanes, receiving the discharge from the impeller, and on the other the return passage to the eye of the next impeller. This return passage is walled by a diaphragm integral with the casting. The water leaving the impeller, guided by the

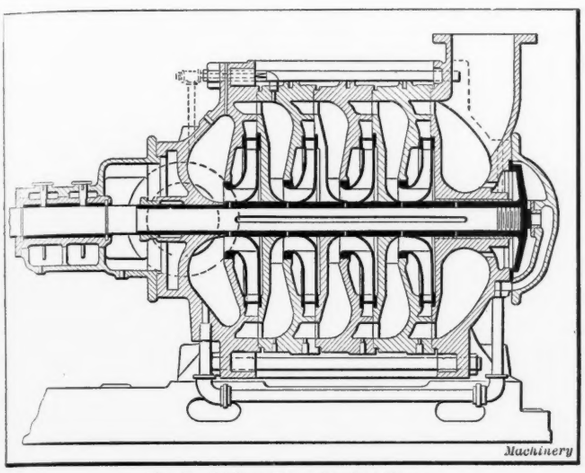


Fig. 7. Modern Four-chamber Pump

delivery vanes, passes to the next chamber and is there guided to the eye of the following impeller.

In comparing such a pump with a modern one (see Fig. 5) it will be found that it is in the form of its impeller and its delivery-casing that the original Mather-Reynolds pump differed most from the present design. The impeller, as shown in Fig. 4, is of the open type (not shrouded), with radial vanes, the roots of which are carried across the openings of the eye into the boss, necessitating the use of a modified form of Francis entrance. This form was probably adopted in order to secure sufficient strength to drive the vanes, necessitating their being carried through full width to the boss on the pump-shaft, and not starting level with the outer diameter of the eye as now. The impeller was turned all over, and revolved a close fit in its casing, which was turned to a corresponding form. This prevented leakage and loss of efficiency by the return of the water from the tip to the suction along the impeller sides.

In the 1895 pumps the speeds of the water through the impeller and passages were comparatively low, and large areas were therefore necessary. Each wheel being of the open type was nearly balanced as to end-thrust in itself, and so with the moderate heads pumped against, troubles with lateral end-thrust were not experienced. There is no doubt, however, that end-thrust did occur, and this caused the impellers to rub on the sides of their casings with consequent friction, the wear causing leakage and loss of efficiency, the varying conditions of which make the true comparison of various tests difficult. This, however, did not cause any serious trouble in practice on account of the large areas on which the end-thrust was taken, and the low head per chamber.

Considering the guide-vanes, it will be seen that in the 1895 pump these are shorter, or rather open out more quickly than in a modern pump. (See Fig. 5.) They are obviously less efficient if judged from the analogy of a Venturi tube, which must have a certain length if serious loss is not to be occasioned by converting velocity into pressure.

A considerable number of pumps of the 1895 form were constructed for installations in this country and abroad. Meanwhile Messrs. Sulzer Bros., of Winterthur, had commenced the manufacture of multiple turbine-pumps about 1896, and had evolved various modifications in the Osborne Reynolds design, whereby both the efficiency and the lifting capacity were considerably improved. They had established in 1898

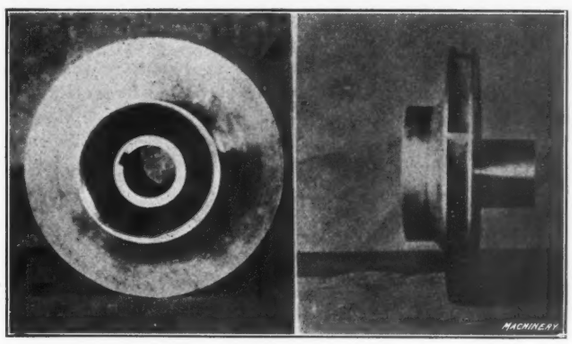


Fig. 8. Impeller of Pump in Fig. 7

an interesting and novel installation of these improved pumps at the Spanish mines of Horcajo, which attracted considerable attention. Two years later an agreement was concluded between Messrs. Sulzer Bros. and Messrs. Mather & Platt, providing for an interchange of future improvements.

A four-chamber pump of the Sulzer design is shown in longitudinal and cross sections in Fig. 6. Comparing this with the 1895 design, three important differences are noticeable. Firstly, the body casting of the pump is constructed in one piece, with the intermediate pieces, guide-vanes, and impellers put in from one end. Secondly, the impellers are shrouded and have backward-curved vanes. Thirdly, the impellers are arranged back to back to compensate for the increased lateral end-pressure set up by the higher heads worked against. This arrangement of the impellers involved the use of somewhat tortuous pas-

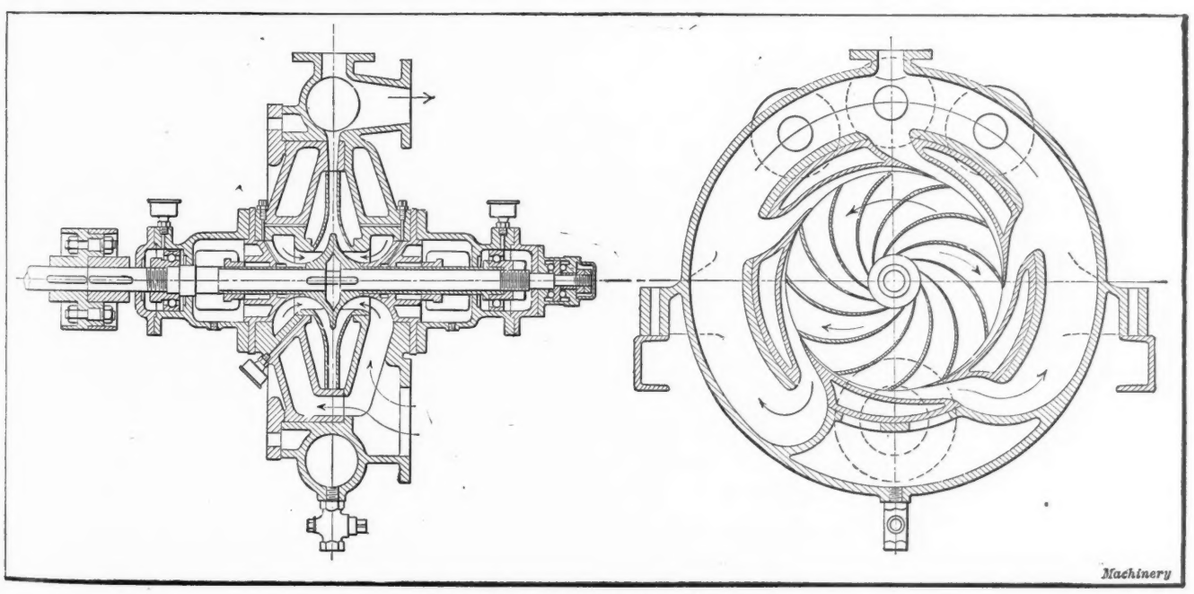


Fig. 9. Single-chamber High-lift Turbine-pump

sages in the pump to bring the discharge of the first impeller to the eye of the second, and so on. Moreover, these passages passing several joints increased the probability of internal leakage from one stage to another. The agreement between Sulzer Bros. and Mather & Platt came to an end by mutual consent in 1904, and after that date each firm further developed their pumps on their own lines.

Proceeding now to the discussion of later designs, a four-chamber pump is shown in longitudinal section in Fig. 7, its guide-vanes being shown in Fig. 5, to the left in the lower view, and its impeller in Fig. 8. It will be seen that constructionally this pump differs principally in that the extended suction-end is shortened, and is similar to the delivery-end. This enables various classes of drives—motor, belt, or steam-turbine—to be better negotiated with a standard pattern. Successive chambers, instead of being secured to their neighbors by bolts and flanges, are held together by long bolts extending the entire length of the pump body and held only at the two ends (suction and delivery).

The impeller is of the shrouded type, having vanes bent well backwards and the guide-passages are longer and more correctly divergent, while the return-way to the eye of the next impeller is of a curved form and more in line and continuous with the receptive ports, thus preventing the abrupt right-angle turn through the casing obtaining in the Reynolds pump. The losses in the Reynolds impeller through side friction in its casing are obviated, and any leakage from the periphery back to the suction is prevented or greatly minimized by the outer circumference of the impeller eye running in neck bushes with a very small radial clearance, amounting to less than 0.005 inch. The importance of preventing this leakage is very great if high efficiency is to be secured. The impeller is turned all over on the outside, to reduce loss by skin friction, and with the same object it is usual to use as many wheels as the circumstances will otherwise allow.

An interesting application of the turbine-pump for fire-prevention purposes, as fitted to petrol automobile fire engines, is shown in Fig. 9. The capacity varies usually from 350 to 1000 gallons per minute, against a head of 250 to 300 feet. The pump has a single chamber and is designed to fit on the back part of the chassis of an automobile, and to be driven by an extended shaft from the engine. The regularity of the flow of water delivered renders the holding of the hose-jets much easier and the action of the turbine-pump allows the shutting off of any particular jet, or of all the jets, without any tendency to burst the hose-pipes, as may be the case with a reciprocating pump. Further, the pump is much lighter than a corresponding pump of reciprocating type, and takes up considerably less space. The difficulties incident to starting with a heavy suction can be met by the provision of a small auxiliary pump which exhausts the suction pipe, thus causing the water to fill the turbine-pump. As soon as the turbine-pump has developed its head pressure, the auxiliary pump can be put out of action, and the turbine-pump will continue to work with suction lifts up to at least 80 per cent of the height of the barometric water column.

* * *

"PRESSURE OF COAL ON STORAGE BIN WALLS"—CORRECTION

The formulas for the pressure of anthracite and bituminous coal given in the February number on page 432, engineering edition, second column, should read as follows:

$$P = \frac{w \times 1.454\, h^2}{2} \tan^2 31^\circ\ 30'$$ for anthracite coal, and

$$P = \frac{w \times 1.574\, h^2}{2} \tan^2 27^\circ\ 30'$$ for bituminous coal in which

form they agree with the formula

$$P = \frac{wh^2}{2} \tan^2 \alpha$$

* * *

The third and concluding installment of "The Forms of Lathe Beds," by Mr. Joseph G. Horner, will appear in the April number.

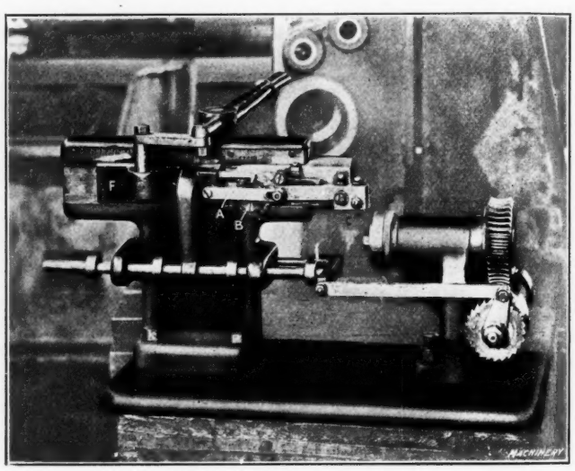
CLEVELAND GRADUATING MACHINE

The halftone shows a simple and effective graduating machine made by the Cleveland Machine Tool Works, Cleveland, Ohio, and used in the manufacture of the Cleveland horizontal boring machines, to graduate the collars of feed and adjusting screws.

The machine comprises a work spindle (at the right in the illustration) driven by a worm and worm-wheel, the collar to be graduated showing at *D;* and a slide at the left which is in two parts, consisting of the part *F* and the tool-slide proper on which the marking tool is mounted. Both slides work in the same guides. The slide *F* is worked by the hand lever at the top, and *F* has an arm projecting downward loosely fitting the horizontal rod *E* on which are four collars. The outer collars limit the travel of the slide, and the position of the middle pair of collars determines the swing of the ratchet indexing lever on the end of the worm.

The form of graduation most used is markings in groups of five, every fifth graduation being denoted by a longer line than those indicating the intermediate graduations. The means by which the variation in length of lines is effected constitute the chief novelty of the machine.

The tool that cuts the lines is fixed just at the left of *C* in the tool-holder. In advance of the cutting tool at *C* is an adjustable hardened stop which limits the depth of the line. This stop is pressed against the collar to be graduated, by the flat spring seen above, so that any irregularities in the work



Cleveland Graduating Machine

do not affect the depth of the line. As stated before, the tool-holder is mounted on a slide moving between the same guides as the slide *F*. It is connected to *F* by the link *A* which is slotted at the right end. Behind the link is a ratchet wheel *B* having every fifth tooth longer than the intermediate teeth. This wheel is mounted on the slide carrying the tool-holder, and is turned one tooth at each stroke of the operating handle by the pawl shown above it. The tool-slide is pushed to the right by a pin in *F*, concealed by *A*, which strikes the end of the ratchet teeth in *B;* and it is pulled to the left by the link *A*. The lost motion or dwell of the slide, due to the slotted link connection, operates the ratchet. The action is as follows:

Suppose that the first four graduations are the short lines. Then the tool is pushed to the right for the minimum length of line. On the fifth stroke, however, the ratchet has turned so that the driving pin strikes on top of the long tooth, and thus the tool slide is pushed to the right an amount greater than the previous four strokes by the difference in height of the long and short ratchet teeth.

Of course the machine is not limited to a fixed order of graduations. Other graduations can be made by using ratchets to suit the required combination of long and short lines.

* * *

The output of steel from electric furnaces during 1910 amounted to almost 112,000 tons in Germany, the United States and Austria-Hungary. There are at the present time in use, or being built, not less than 118 electric furnaces of all types.

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THE NEW PLANT OF THE CINCINNATI MILLING MACHINE CO.*

Some years ago, when the Cincinnati Milling Machine Co.'s business had grown beyond the capacity of the old plant, Mr. Fred A. Geier, president of the company, conceived the idea of organizing a factory colony grouped about a central power plant. Three other companies that were in need of better facilities joined at once in this project, and the outcome of the idea is the factory colony at Oakley, situated forty minutes by trolley from the business center of Cincinnati. Seven plants are now located there. In the present article the new plant of the Cincinnati Milling Machine Co., as built in this location during the last three years, will be described. In many respects this plant is one of the most remarkable factory buildings in the country. It is apparent to the observer that a great deal of thought has been expended to secure, as nearly as possible, ideal shop conditions with regard to mechanical arrangement, light, heat, ventilation and sanitation. It is no exaggeration to call these works a model plant, constructed and equipped for the highest efficiency.

General Arrangement and Character of Plant

A bird's-eye view of the entire plant is shown in Fig. 1, while Fig. 2 shows an outline plan of the buildings, indicating their relation to each other and to the railway tracks, etc. The total floor space of the whole plant is 275,000 square feet; the machine shop proper is 585 feet long, and the three-story building facing south has a length of 380 feet. A general idea of the size and arrangement of the machine shop may be obtained from the interior view Fig. 3.

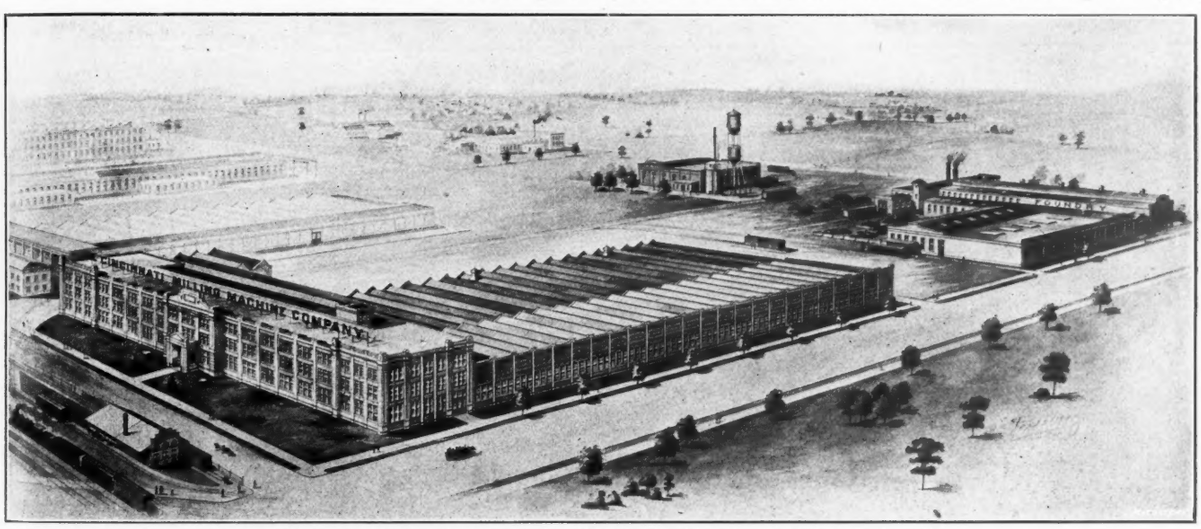

Fig. 1. The New Plant of the Cincinnati Milling Machine Co., at Oakley, Cincinnati

The first section of the machine shop was erected in 1909 and 1910, and was operated in connection with the old plant until the three-story section was completed in the fall of 1911. The machine shop proper is a single-story brick and steel building, 16 feet high under the trusses, and 26 feet under the peak. A 60-foot section along the eastern side of the building is 21 feet under the trusses, and is traversed by 5-ton traveling cranes. The roof is of concrete and steel, covered with Carey roofing. It is supported by hollow cast-iron columns of small diameter, thus avoiding that sense of obstruction which is sometimes present in shops using built-up steel columns. The hollow columns also serve as down-spouts. The roof trusses are provided with gusset plates to facilitate the placing of countershafts and crane-ways in either direction.

The floor is of reinforced concrete, 8 inches thick, so that individual foundations for the machines, except in the case of the largest planers, are unnecessary. The heavy concrete floor also provides for that stability in the assembling and testing departments which is essential for satisfactory working conditions. That part of the shop which is occupied by the planers has a floor 16 inches thick, to carry the weight of the smaller planers and the masses of heavy material in process of manufacture which are grouped about them. In preparing the ground for the concrete floors the sod was thoroughly removed and the surface was rolled with a 10-ton roller, after which it was leveled and rolled a second time. A covering of tar felt was then placed over the entire surface, and the concrete was placed directly on this covering. The reinforcement consists of ¼-inch twisted bars laid at right angles with each other and spaced 12 inches apart, the bars being wired together at all intersections. This kind of floor proved so satisfactory during more than a year's use in the first part of the building that it was adopted without hesitation for the addition recently completed.

The three-story south front of the building is of reinforced concrete construction faced with brick. The first floor is a continuation of the one-story shop. The upper floors, each covering an area of 380 by 60 feet, provide quarters for the various offices and space for those departments which should preferably be separated from the main machine shop. Thus the third floor contains the general offices, and the engineering and clerical departments. This floor was selected for the offices because of the desirability of having them on the floor highest above the ground level on account of being more quiet, cleaner and better ventilated. Access to the office is by means of an elevator. The western end of the third floor contains an auditorium, having a seating capacity of 600 people, and is also provided with a kitchen and dining rooms. The floors of all the offices, as well as the floor in the main entrance to the building, are laid with ceramic tiling with a 6-inch sanitary base of green tile.

Immediately adjoining the engineering department on the east is the toolmaking department, this arrangement bringing the latter into close touch with the tool-designing department. In general, as indicated in Fig. 2, the principle of placing all related departments adjacent to each other has been adhered to, and this principle has been carried out in the offices to the same extent as in the manufacturing departments.

The second floor is devoted to stock-rooms for the finished parts, and also to the assembling of cutter grinders, and milling machine attachments. This is the only manufacturing done outside of the main machine shop floor. One portion of the second floor was also especially set aside to provide a place where the dividing heads could be assembled, as experience had shown that this precision work could be done more satisfactorily in an isolated department.

The Shop Departments

When the factory colony at Oakley was decided upon, the Cincinnati Milling Machine Co. retained seventeen acres for

* For descriptions of other of the new plants located in the Oakley factory colony, see MACHINERY, July, 1911, engineering edition, "Cincinnati-Bickford Tool Co.'s Plant at Oakley, Cincinnati"; March, 1911, engineering edition, "Interesting Tools and Methods of Cincinnati Shops—The Cincinnati Planer Co."; June, 1910, "The New Cincinnati Planer Plant," and "Opening of New Plant of Triumph Electric Co. and Triumph Ice Machine Co."

foundry and machine shop purposes. The first building erected was the foundry, which is run as a separate organization known as the Modern Foundry Co., but owned by the stockholders of the Cincinnati Milling Machine Co. This foundry has a daily melting capacity of 30 tons of iron for machine-steel castings, all of which, including the largest milling machine column castings, are made on molding machines. As shown, the foundry is located to the north of the machine shop, with which it is connected by an industrial track. A depressed railway siding connects with this industrial track over which all the raw materials enter the north end of the machine shop.

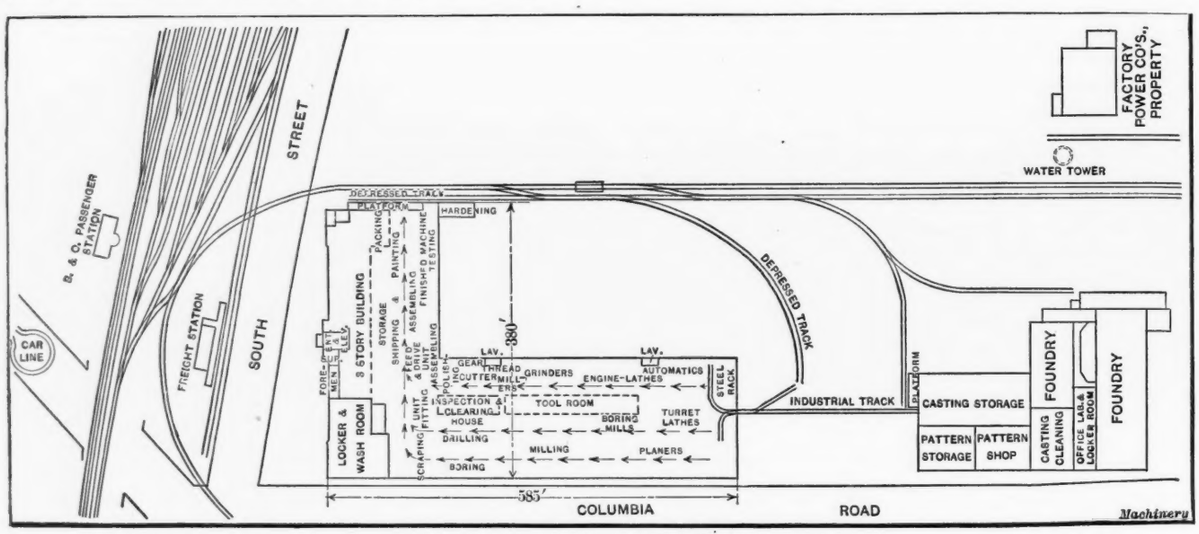

Fig. 2. General Plan of New Plant

In some cases, however, this arrangement has not been found desirable, and the motors are then mounted in the ceiling directly over the machines.

Adjoining the automatic machines are the engine lathes, arranged in four rows, the two center rows being placed close together, back to back, with an ample aisle space between each of these and the outer rows. Next to the lathe depart-

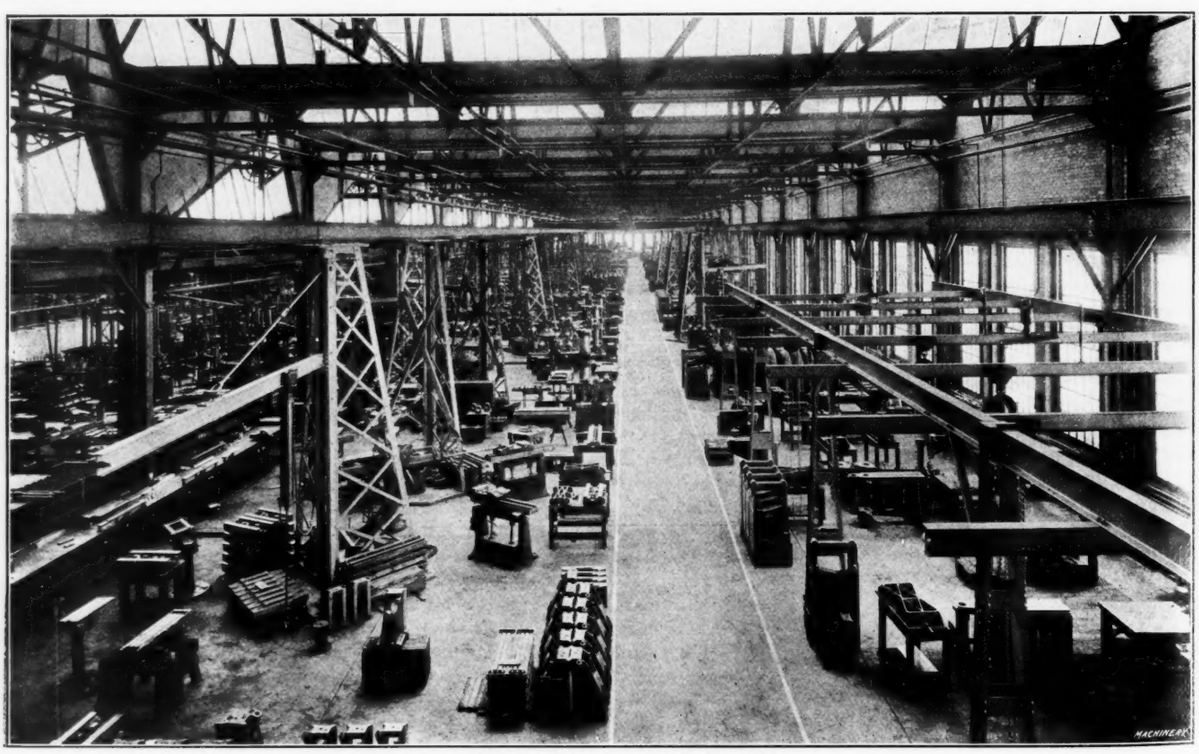

Fig. 3. General Interior View of Machine Shop

As indicated in Fig. 2. the various departments are located with relation to each other in accordance with the sequence of operations. Hence the automatic screw machines and turret lathes are placed at the extreme north end, these machines performing the first operations on bar stock and on small castings, drop forgings, etc. On one side of these departments are racks upon which are stored all the bar steel adjacent to the machines. The machine equipment, in general, is highly specialized, and many machines are especially fitted up for certain work which is never done on any machine except the one so equipped. There are also many special machines which have been designed and installed mainly to improve the quality of the work. Some extremely large bar work is done on automatic machines, the largest automatics taking bars up to 6¾ inches in diameter. Individual motor drives are largely used, the motors being mounted directly on the machines.

ment is the grinding department, and adjacent to this are the thread milling and screw chasing machines. Here all short screw threads are milled, while long lead-screws are made on automatic thread chasing machines. Next to the thread millers are the gear cutters, the equipment including a Gleason bevel gear generator, and two special tooth-rounding machines. The latter have been designed and built by the

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company to meet its own special requirements. Special testing devices are provided, on which all gears are tested on fixed centers placed at the correct theoretical distance apart. The gears must show a proper bearing and must revolve freely without pinching or backlash when testing. The 20-degree pressure-angle form of tooth has been adopted because of its greater strength, and the cutters for each gear are especially developed for the correct number of teeth for that gear. The cutters are made in pairs for the two gears that work together. Proper running clearances between the gears are provided in the completed machine by arranging their final center distances a few thousandths inch farther apart than the theoretical distance.

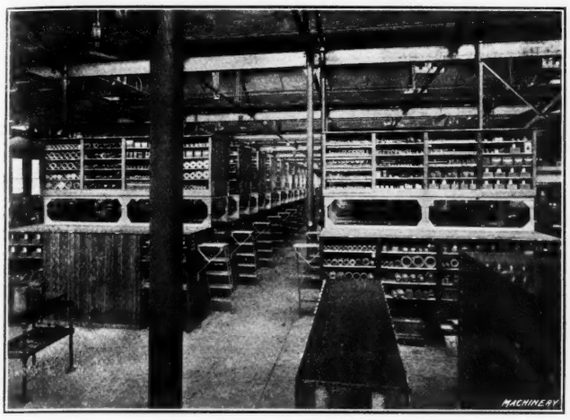

Fig. 4. A View in the Tool-room

Tool-room—Inspection and Routing Department

The tool-room, as indicated in Fig. 2, is located as nearly as possible in the central section of the main manufacturing department, and comprises a floor space of 28 by 200 feet. A general view of this department is shown in Fig. 4. All jigs, tools, and fixtures, except some very large ones, are kept in this department, and may be withdrawn only on the presentation of workmen's checks and a shop order, the latter showing the part number and the operation for which the jig is wanted. A carefully planned system is used for taking care of the tools, and an arrangement is introduced which economizes space and gives easy access to all the shelves on which the tools are stored. This tool-room is distinctly a storage and distributing room, no toolmaking or repairing being done here, except that all cutting tools are sharpened here immediately upon their return from the manufacturing departments, and before being again placed on the shelves. Every tool, jig and fixture is inspected after having been used, and, if in need of repairs, is sent immediately to the toolmaking department. Because of the large size of this tool-room, there are three windows, one of which serves the drilling, fitting, and gear-cutting departments, one, the screw-cutting, grinding and engine lathe departments, and the third, the turret lathe, milling and planing departments.

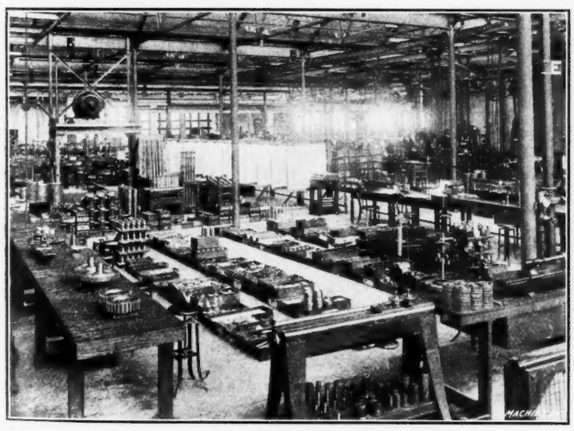

Fig. 5. Inspection and Routing Department

Immediately adjacent to the tool-room is the inspection department shown in Fig. 5. Here all the parts are inspected after each machining operation, the necessary gages, indicators, etc., being conveniently provided. All hardened gears, clutches and similar parts are tested with the scleroscope, definite standards of hardness having been determined upon for each part. The routing department is also located here. The large charts shown in the center of Fig. 5 contain a record of every piece passing through the shop, indicating which department it is in and, therefore, which operation is being performed on it, and also the date when each succeeding operation must be finished. In this way absolute control is kept over the movements of every individual piece and operation.

After having passed the final inspection, the finished parts are delivered to the stock-room shown in Fig. 6, where they are placed on shelves and await withdrawal for assembling.

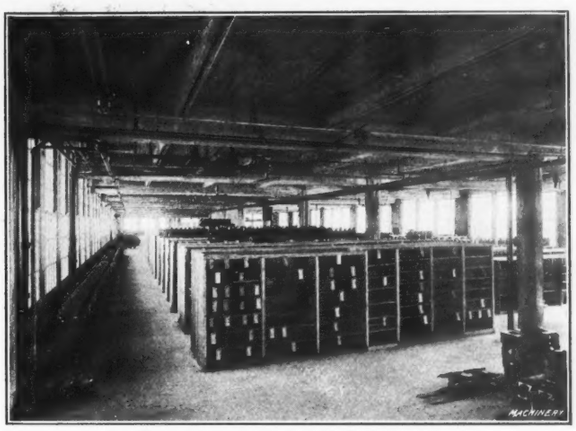

Fig. 6. Stock-room for Finished Parts

An accurate record of receipts, withdrawals, and balance on hand of each individual part is carefully kept on the bin-slips attached to each shelf, a number of which are shown in the illustration. As already mentioned, this stock-room occupies part of the second floor of the three-story building. It is located close to the elevator, which is immediately adjacent to the assembling department on the machine shop floor. The remainder of the second floor, as also mentioned, is devoted to the assembling of cutter-grinders and milling machine attachments. This department is illustrated in Fig. 7. In this view are also shown some of the details of construction of the concrete building. The cast-iron-lined bolt-slots in the bottoms of the girders for suspending the countershafts, and those at the tops of the columns for attaching crane runways, are of special interest.

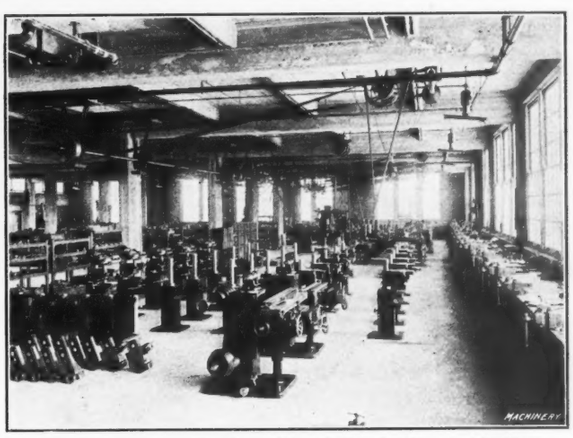

Fig. 7. Department for Assembling Cutter Grinders and Milling Machine Attachments

Planing, Milling and Boring Departments

All the large castings when entering the north end of the building are carried by the industrial track to the planing department, Fig. 8. The planers are all driven by individual motors. A number of them have 40-foot beds, the largest of them being the 72-inch by 72-inch by 40-foot planer, shown in

the background at the extreme right. The planers are all provided with a variable cutting stroke and a constant return stroke of 100 feet per minute. After leaving the planer department, the castings pass on to the drilling, milling and boring departments, as required.

A section of the milling department is shown in Fig. 9. The machines are grouped according to size and with regard to the nature of the work done on them. All of the larger machines are provided with individual motor drives and are located under the traveling cranes. A row of vertical milling machines along the wall is served by jib cranes, and similarly a row of large horizontal machines placed on the other side of the main aisle are also served by jib cranes. The space between these machines is entirely clear and available for handling the work. The machines face the jib cranes to facilitate swinging the large castings onto and off the machines.

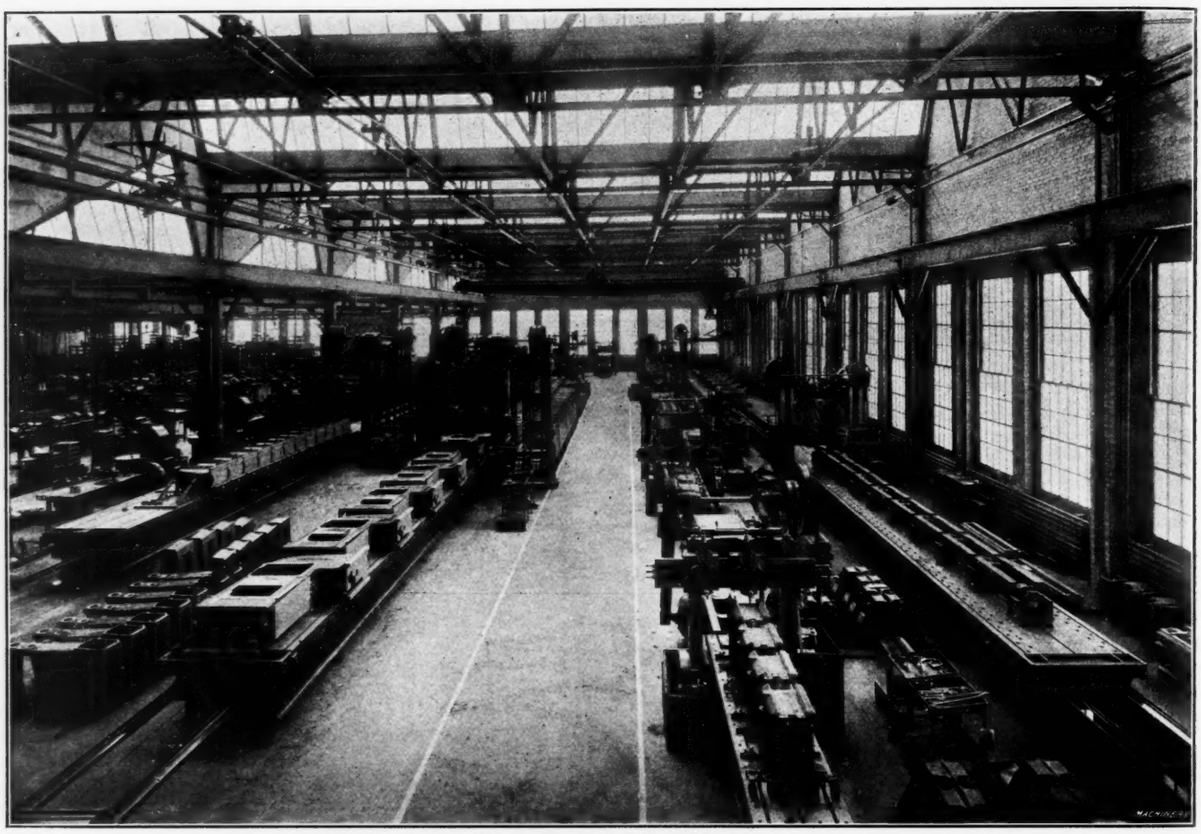

Fig. 8. The Planing Department

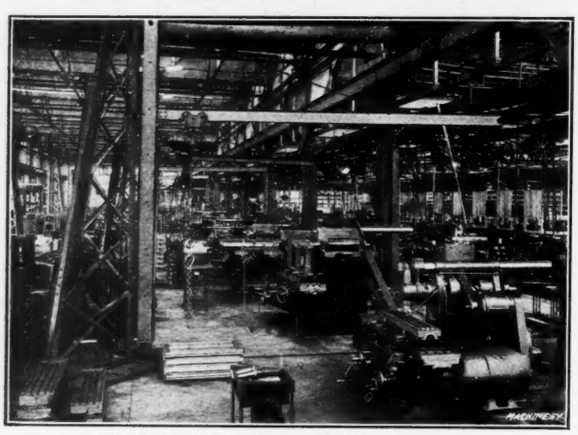

Fig. 9. Part of the Milling Machine Department

The smaller machines are belt-driven and are arranged in two parallel rows, but in this case they are placed back to back instead of facing each other. The radial drills, which are chiefly employed on large castings handled by jib cranes, are shown in the center of Fig. 3, under the traveling cranes.

The column boring department is shown in Fig. 10. The faces of the columns are first rough scraped, and then the columns are placed in a specially designed machine which bores the spindle hole and the supporting or over-arm hole simultaneously. This machine is shown in the center of the illustration. The boring bars are in a vertical position. They may be operated simultaneously or independently, and either for boring or facing. The correct distance between the holes and their parallelism is taken care of entirely by the guides of the boring bars. The guides for the outer bar are removable and are provided in proper sizes for each size of column. The holding device on the bed of the machine locates the column central with the boring bars, which are connected with the driving spindles by a bayonet lock, facilitating quick and easy release, and providing sufficient play to allow the bars to revolve freely, regardless of the lack of alignment with the driving spindles.

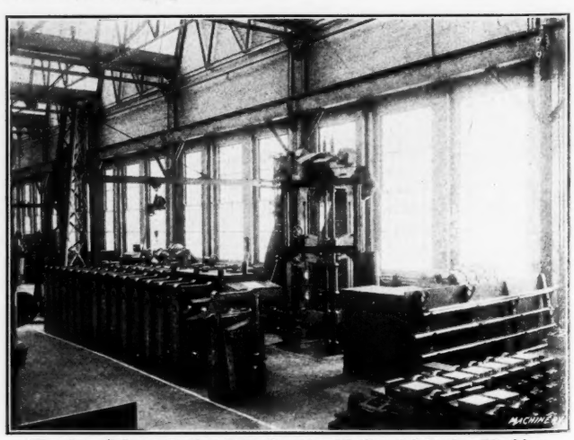

Fig. 10. Column Boring Department with Special Boring Machine

An entire lot of columns of one size is bored without taking the bar out of the machine. When one column is finished, the bars are lowered out of the way, and raised again, when the next column is in place, by means of compressed air. The bed of the machine is moved clear of the housing when chucking the work, it also being operated by compressed air. There

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are two sets of operating levers, and the operator is provided with an elevator, the framework of which is shown in the front of the machine, for changing his position readily.

The chief consideration which led to the building of this machine was to obtain the highest possible accuracy rather than quantity of output. After the columns have been bored they are tested for accuracy by an inspector located in this department. The column in the foreground shows a testing instrument in place for examining the accuracy of the spindle holes with regard to their being at right angles with the

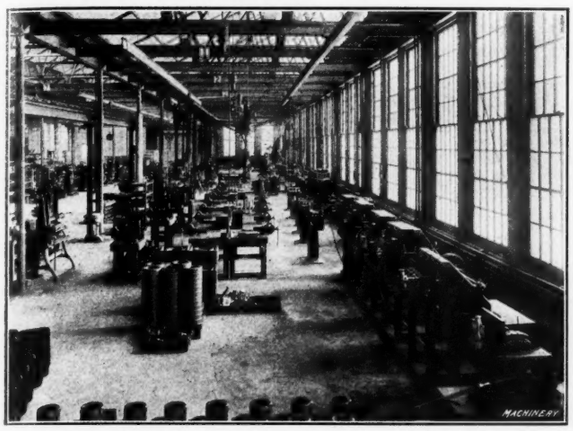

Fig. 11. Department for Assembling and Testing Feed and Drive Boxes

column face in both the vertical and horizontal direction. Further tests are made for parallelism, diameter, distance between over-arm and spindle holes, etc. A record of these tests accompanies each column to the fitting department. This inspection does not take the place of the final accuracy test to which the finished machine is afterwards subjected.

Scraping and Assembling

The large machine parts, such as columns, saddles, etc., next arrive at the scraping department shown in the foreground of Fig. 3. All the scraping is done to surface plates and master

Fig. 12. A Corner of the Department for Assembling Dividing Heads

gages. In this department there are a number of interesting devices, as, for example, a swiveling arrangement for holding the tables for the scraping operation, enabling the workman to always bring the surface worked upon into a horizontal position. Another interesting device is the so-called "scraping machine" at the left of Fig. 3, between the first two jib cranes. This is a hydraulic cylinder fitted with reversing valves which give the piston a continuous reciprocating movement. This device is used for sliding large parts on each other, to determine the accuracy of their bearings. The device is arranged to swivel, and it may be elevated by hydraulic means to suit the height of the different parts. The column scraping is done under the framework at the right of the picture, the framework forming a number of parallel runways for hoists.

Fig. 3 also shows the extent to which crane service and hoists are provided. The main traversing cranes are of five-ton capacity with 60-foot span. These cranes serve all the planers at the far end of the building and transport material from one department to the other. The individual machines, other than the planers, are served by self-contained jib cranes. The steel work of the jib crane is fastened to and supported by a large cast-iron base. The mast rests on a ball thrust bearing, consisting of a single ball of large diameter. These cranes are not a permanent part of the building, but are bolted to the floor and can be placed in some other part of the shop at any time that it may be desirable to do so.

The assembling department for feed and drive boxes is shown in Fig. 11. In the foreground is shown the testing stands on which each feed box and each drive box is given a running and endurance test under conditions which duplicate those under which it will operate when placed on the machine. In the immediate foreground is shown the driving clutch pulley testing stand on which the units entering into the single-pulley high-power machines are given a running and load test. This stand is provided with a prony brake and an ammeter which indicates the load applied under each test.

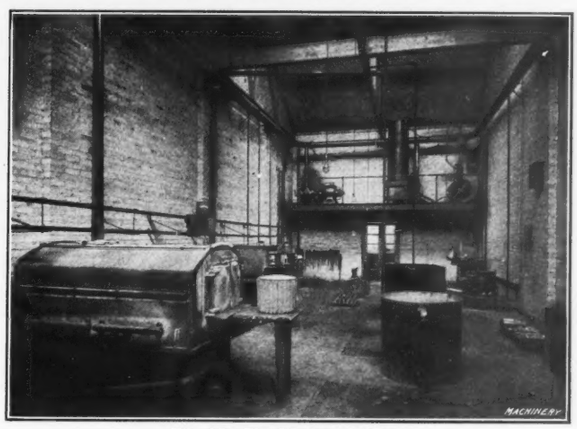

Fig. 13. The Hardening Room

Fig. 12 shows a corner of the dividing-head department. As already mentioned this department is purposely isolated, because of the precision work required. On completion, each dividing head is subjected to the most rigid accuracy tests, and a copy of each test is filed. The dividing-head worm-wheels are hobbed on a machine especially designed for this one operation. The worm-wheels hobbed in this machine will index work 8 inches in diameter with an average accuracy of 0.00025 inch of accumulative error in any one quarter of the circumference.

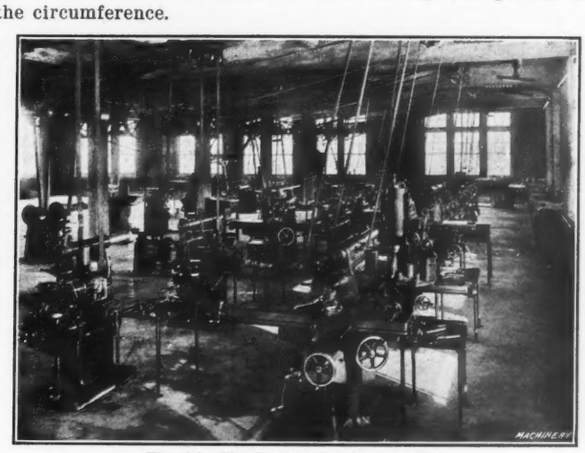

Fig. 14. The Toolmaking Department

The carbonizing and hardening department is shown in Fig. 13. In addition to the clutches and other small parts, a large number of the gears entering into the milling machines manufactured are hardened. The hardening department is equipped with gas furnaces and lead baths. Temperatures are determined by a pyrometer mounted on a track over the furnaces. The pressure blower is motor-driven, and a gas engine is also installed for emergency service, so as to provide for the necessary continuous carbonizing. Two oil tanks immersed in running water are placed in the floor. They are provided with steel covers for closing them when not in use.

Since the toolmaking department does not make any part

used in the products of the shop, there would be no advantage in having it located with the manufacturing departments. On the other hand, there is an advantage in having it located by itself, and, therefore, it has been placed on the third floor so as to be close to the tool-designing and engineering departments. This department, a view of which is shown in Fig. 14, is equipped with all the machine tools necessary for toolmaking, including a cylindrical grinder, an internal grinder, and a surface grinder, so that there will be no need to call on any of the manufacturing departments for assistance, except in the case of an unusually large planer job for a heavy fixture. No shapers are employed, all the work of a character for which shapers could be used being done on milling machines.

Fig. 15. Department for Testing the Completed Machines

As the new model milling machines built by the company are constructed entirely according to the unit system, the final assembling consists merely in assembling such units as feed boxes, drive boxes, driving clutch pulleys, etc., into one complete machine. After the machines have been assembled by successive groups of men, each attaching one class of units, they arrive at the final testing department shown in Fig. 15. Here each machine is given a thorough test for accuracy of alignment, and a running test under belt for a specified length of time. Each machine must also do a specified amount of milling. A permanent record is kept of all these tests.

Adjacent to the testing department are the shipping and

Fig. 16. The Packing Department

packing departments, the latter of which is shown in Fig. 16. There are two shipping doors leading to the shipping platform. The one in the center of the illustration is provided with a vestibule for the protection of this part of the shop during severe weather. They are closed by steel drop doors and are entirely surrounded by circulation pipes of the hot water heating system. The railway cars come up to the shipping platform on a depressed track so that the floors of the cars are level with the platform. Three cars may be loaded at one time.

Washrooms, Sanitation, etc.

The employes' entrance on the Columbia road side (see Fig. 2) leads directly into the service room where ventilated steel individual lockers are provided for all the men. The wash basins are of the individual type with hot and cold water, and there is one basin for every three men. Hot water for this room and for the shower baths is obtained from instantaneous heaters, one of which is shown in Fig. 17.

The sanitary arrangements are of the very best. The toilet rooms are marble lined, and all metal work is nickel-plated, these materials having been selected in order to keep everything in a sanitary condition. The shower baths for the use of the employes are also built of marble, each compartment being divided into two sections, with a bath in the rear and a dressing room in the front. Sanitary drinking fountains are provided at intervals throughout the shop.

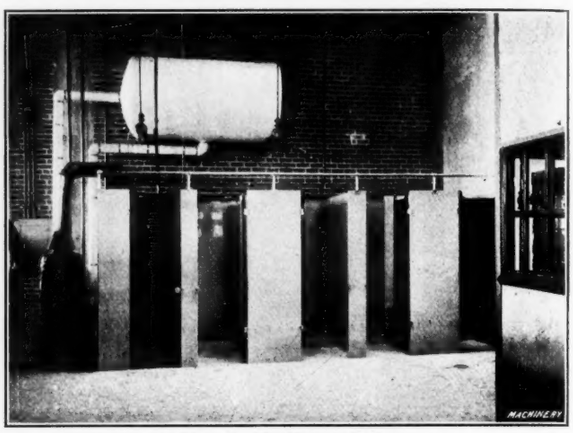

Fig. 17. The Shower Baths

The manufacturing departments are lighted by Cooper-Hewitt lamps which furnish sufficient illumination for all purposes without the use of individual lights, with the exception of a few special cases. The offices and engineering departments are lighted by the indirect system using tungsten lamps in clusters. This soft, diffused and evenly distributed light has proved as satisfactory as good daylight. The buildings are heated by the Evans-Almirall system of forced circulation hot water. In the single-story part of the building, the circulation pipes are placed on the lower chord of the trusses, immediately below the window space, as indicated in Fig. 16. This arrangement prevents drafts caused by descending cur-

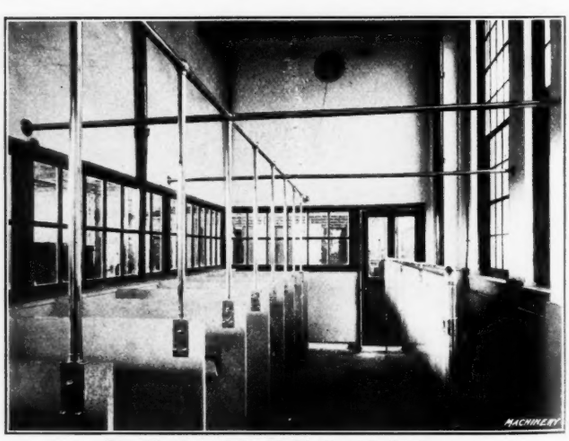

Fig. 18. One of the Marble-lined Toilet Rooms

rents of cold air from the roof windows, and has proved satisfactory during the extreme cold of the present winter. The provisions for ventilation have also proved sufficient during the extremely hot weather of the past summer. The arrangement of the roof windows permits the opening of the entire upper one-third of the sash, providing for 60 square feet of opening for each 500 square feet of floor space, the liberality of which is evident when compared with the usual arrangement of one 48-inch ventilator for every 100-foot length of roof, providing only 12 square feet of opening for each 2500 feet of floor space. The sash opening devices are operated from the floor, and in some cases as much as 100-foot lengths of sash are controlled from a single point.

APPLICATIONS FOR PNEUMATIC TOOLS

By A. M. M.

There are many classes of work now done by hand to which pneumatic tools can be applied with advantage. Many plants have developed special uses for these tools, a few of which are here presented.

A contractor engaged in erecting large electric generators had several thousand tubular rivets, 1½ inch in diameter, which were to be headed cold. This was a very slow and laborious job. The rivets were used to hold together the laminations of the stator, and were drilled at the ends to make them tubular and to facilitate heading. By means of a beading tool and a hand-hammer, they could be riveted up in the same manner that boiler tubes are beaded, but it was found that not more than two per hour could be headed by hand. After considerable experimenting a 9-inch pneumatic riveter was fitted with a special die for the work, and the time was reduced to five minutes per head, with less fatigue to the operator.

Fig. 1, showing the die and rivet end, illustrates the idea. A common riveting die was turned to fit the finished head, leaving a centering pin in the middle of the die. Two opposite sides of the die were then slabbed off on a milling machine, leaving the working edge about ⅜ inch thick. This edge was filed round, and the die hardened. A hole drilled through the die provided means for attaching a piece of ⅜-inch round steel wire as shown. This served as a handle to rotate the die. The operator could form a perfect head on the bolt by slowly rotating the die, and working down the edges as desired.

Hardening Riveting Dies

Many concerns have trouble with the breaking of riveting dies. One large company using about thirty riveters broke on an average ten dies per day. As these dies cost about $1.75 each, it will be seen that the total expense was considerable. The blacksmith hardened the dies only at the cup and shank, leaving the shoulder soft. He decided that as all the dies were breaking at the shoulder, he would leave that part as soft as possible. Many blacksmiths make the same mistake. The trouble, however, is that the tension set

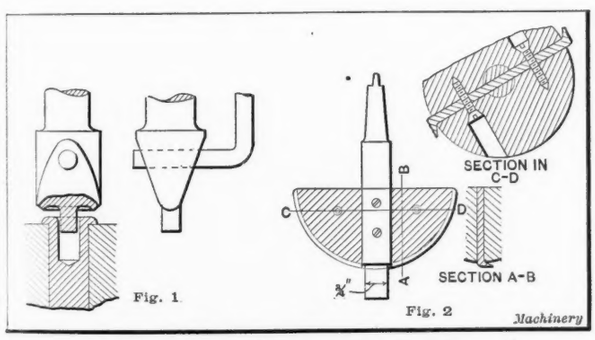

Fig. 1. A Pneumatic Beading Tool. Fig. 2. A Pneumatic Wood-cutting Tool

up by the uneven hardening causes the breakage. The following method of hardening was adopted, and the breakage fell to one die per week or less, instead of ten per day.

A die was first heated slowly and evenly to a temperature considerably higher than that required for the hardening. It was then allowed to cool for several minutes to insure that the interior of the die was as hot as the outside. It was then (at a dull red heat) quenched in oil. The blacksmith had previously prepared a ring or tube rolled up from a piece of ¾ inch plate. This tube was about 6 inches in inside diameter and 10 inches long. It was heated to a bright red heat, and the die held in the center of it to draw its temper evenly. When the right color was reached, the die was quenched in water. Dies hardened in this manner gave excellent results. A steel costing 12 cents per pound was used.

Driving Drift-bolts in Crib Work

A contractor was building crib work of hard fine timbers, 16 inches square. He had several thousand drift-bolts to drive. The bolts were 8 feet long, and 1 inch in diameter. He had several gangs of three men each working from a staging, driving with heavy sledges. The three men would drive one bolt, striking alternately. The work was progressing so slowly that he determined to try a pneumatic riveting hammer. He found that a heavy riveter, operated by one man, would do the work of two gangs (six men), and dispense with the heavy staging.

Use of Pneumatic Hammer in Broaching Operation

A machine shop had a large number of hexagon bushings whose inside surface had to be finished smooth and of accurate dimensions to make a close fit on a ¾-inch hexagon rod. A hexagon broach of the same dimensions as the rod was machined and the end squared off to a cutting edge. It was found very difficult to drive this tool through the bushing with a hand hammer, but it was easily and quickly accomplished by the rapid blows of a pneumatic hammer.

A Pneumatic Wood-cutting Tool

It often happens that wooden hatches or decks are fitted with I-bolts or handles which must lie flat with the surface.

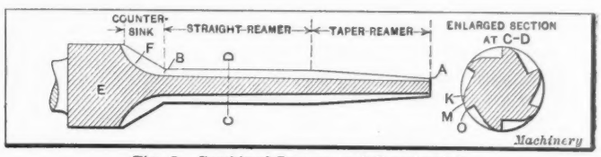

Fig. 3. Combined Reamer and Countersink

To make room for the fingers or a rope under the ring, the wood must be cut out in the form of a cup or depression. Often, on a large job, there will be several hundreds of these cups to hollow out of the flat surface. A carpenter with his gouge and mallet will take a couple of hours to finish one, but the cutter here described, fitted to a pneumatic machine, will do this work in a few minutes. The cutter blade is formed of ¼-inch tool steel plate, set into a slotted bar and brazed. After this operation is completed, a block of wood, turned in a wood lathe to the shape of the cup, is fitted to it as shown in Fig. 2. This block allows the cutter to project beyond its surface, and prevents it from taking too large a chip. The tool works best in one of the smaller machines of high speed. A ¾-inch guide hole is first bored to the required depth.

Special Reamers for Pneumatic Tools

In a plant handling structural or steel ship work, the reaming and countersinking of the thousands of rivet holes is a large item, and may represent a considerable percentage of the cost of construction. It is important that the reamer with which this work is done shall have certain properties. It must cut rapidly, without heating. It must clear itself when forced, without breaking. It must stand the abuse of unskilled labor. Two men with an ample supply of sharp correctly made reamers will ream several thousand holes per day, where they will only ream several hundred if obliged to work with reamers which do not cut properly. The following description and illustration, Fig. 3, shows how one of the large shipyards increased the efficiency of this operation several hundred per cent by giving careful attention to these points.

This yard had a million, more or less, ¾-inch rivet holes to be reamed and countersunk. The work was started with the ordinary pneumatic reamers and countersinks, making two separate operations. The tool-room, having only a small supply of these tools and having other troubles, was very "economical" in handing out reamers, and kept the men working with the tools long after they were too dull to cut properly. The consequence was that the men would keep a reamer turning in one hole for several minutes, and not only did it not work, but the reamers were burned. The men made no attempt to rush the work as this only resulted in burned reamers and a "call-down" from the tool-room.

The following system was adopted with an increase of about 500 per cent in the amount of work turned out. A special combination reamer and countersink was designed as shown in Fig. 3. Enough of these tools were provided to allow about four reamers per gang. The gangs were put on piecework

and one skilled operator in the tool-room was made responsible for keeping the reamers sharp. Each gang was given a can of tallow in which to lubricate the reamer as often as required. The gangs working on the flat decks were cut down to one

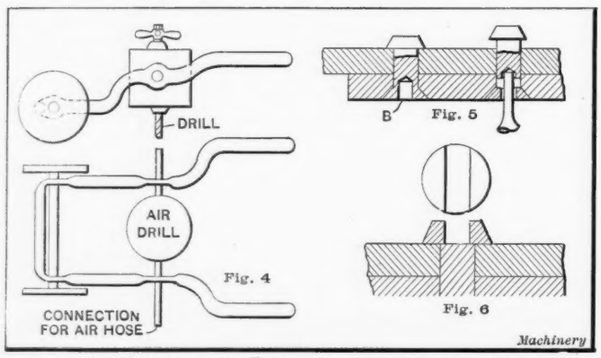

Fig. 4. A Substitute for the "Helper." Fig. 5. Method of Removing Rivets. Fig. 6. Method of Cutting-off Rivet Heads

man, and this man was provided with one of the "wheelbarrow" devices shown in Fig. 4, in place of his "helper." All extension shanks were inspected and those having damaged sockets were thrown out and replaced with new ones of tool steel with close-fitting sockets. Many of these shanks were found to be made of soft steel, and the socket which received the Morse taper shank was so cut out as to allow the reamer to jump out and turn in the socket. Many reamers were ruined by having the small ends of the shanks twisted off. All of these shanks should be carefully made of tool steel. The countersink-reamers insure that the countersink will be concentric with the reamed hole, and the whole job is done at one operation.

These reamers are turned out of solid stock ("22-cent" tool steel, box annealed) of the diameter of the countersink-portion *E*. In milling, a single straight cut is made from *A* to *B*, and the milling cutter is of a diameter to form the curve at *F*. This is not an ideal method, but it saves several resetting operations and is satisfactory in practice. Care is taken to grind off the back of the tooth to the proper angle at *K*. A cutting edge must be made with the clearance from *M* to *O* less than at *K*, and is the only portion ground in resharpening.

Easy Way of Cutting out Rivets

An easy way of cutting out rivets is as follows: First drill a hole as shown in Fig. 5 at *B*. Then use a backing-out punch made to fit a pneumatic riveting hammer. If a good backing is available, a pneumatic "jam hammer" can be used to advantage. For cutting off rivet heads proceed as in Fig. 6, using a pneumatic chipping hammer and "cape" chisel. First cut a slot through the head, making it like a slotted screw-head. The two sides can now be cut off without trouble.

* * *

Just so much of forms, rules and regulations as will insure that the right thing will be done in the right manner at the right time, is system. Whatever is more than that is red tape.

MAGAZINE ATTACHMENTS—2

APPLICATION TO THE BROWN & SHARPE AUTOMATIC SCREW MACHINES

By DOUGLAS T. HAMILTON*

Small pieces which have been partly completed in the punch press can be handled satisfactorily in a Brown & Sharpe automatic screw machine by the application of a magazine attachment. The type of attachment to use depends entirely on the shape and character of the work. In the February number, a few of the more simple attachments were illustrated and described. In this article is given a description of three attachments and their auxiliary mechanisms for handling parts blanked out in the punch press. Reference is made to Figs. 5 and 9, which appeared in the February number.

A Snake-shaped Attachment

Fig. 11 illustrates a snake-shaped slide which is used for handling the watch crowns shown at *N* and *O* in Fig. 9. The sectional views of this slide show the shape of the different crowns for which this attachment is used. Of course special slides were made for each different size. The slide shown in Fig. 11 is held in a bracket similar in construction to that shown at *A* in Fig. 12. The watch crowns are made from sheet metal, which is drawn up and formed around a solid

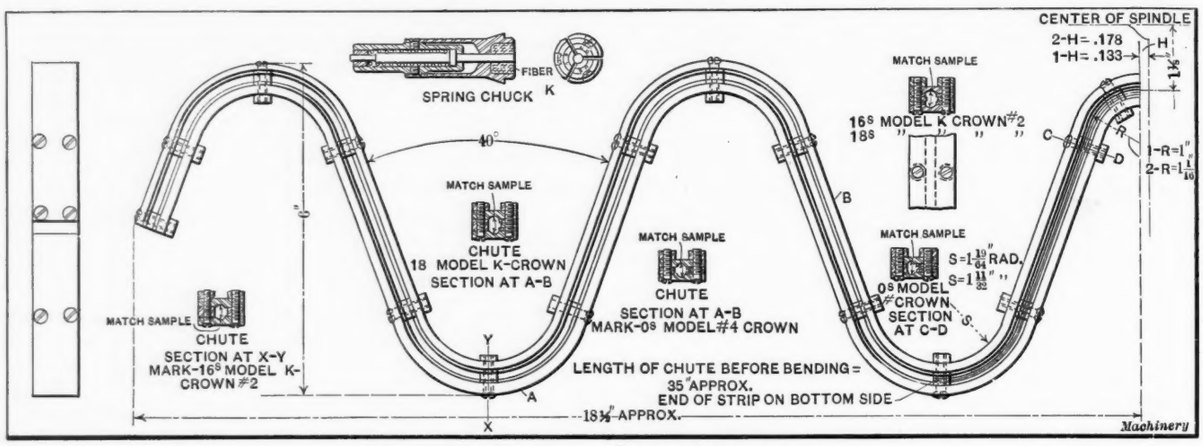

Fig. 11. Magazine Attachment for Handling Watch Crowns

center in the punch press. The knurling on the crown is also produced when it is being formed. The reason for making a crown in this manner is that it can be made from "rolled plate," the name given to a class of material used in

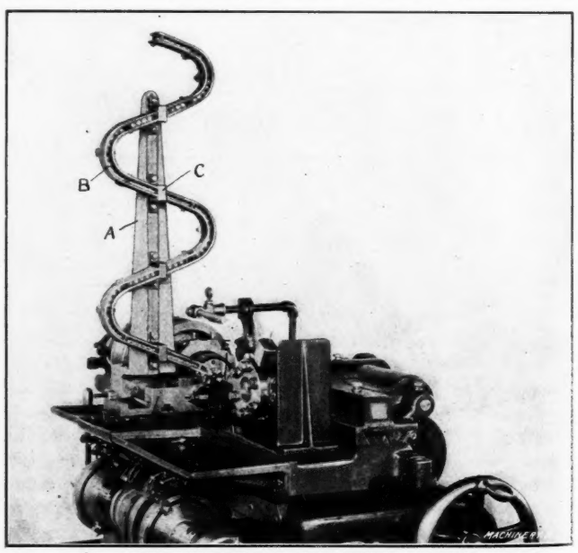

Fig. 12. Snake-shaped Attachment for Handling a Shouldered Stud on a No. 0 Brown & Sharpe Automatic Screw Machine

the manufacture of jewelry, which consists of a block of some composition, such as brass, to one side of which is soldered a thin sheet of gold; this block is then rolled out into sheets

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of the desired thickness and cut up and formed in a punch press. This facilitates the production of an article which is much harder than gold, will not corrode, and wears well.

Referring to Fig. 11, this slide consists of two strips *A* and *B* held together by screws and separated by blocks. The strips are milled out to suit the work which is to be placed between them. There are two reasons for having the slide of this attachment made in this manner: First, being bent into the shape shown, it will hold a greater number of pieces in

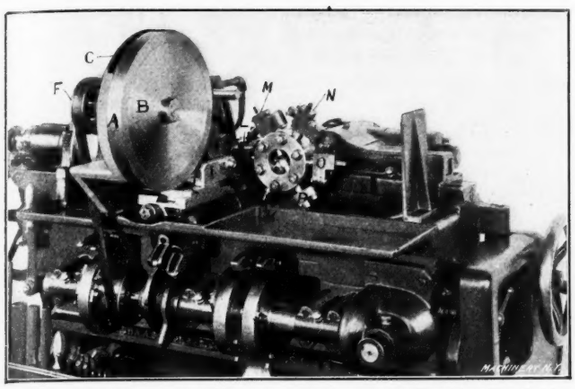


Fig. 13. Semi-automatic Magazine Attachment for Handling Blanks for Watch-spring Barrels on a No. 0 Brown & Sharpe Automatic Screw Machine

the same height, thus making it more accessible to the operator; second, it gives a practically vertical slide at the curved point, which assists in feeding the work to the machine. The work is carried from the slide to the machine by a carrier, a description of which will be given later. The chuck for holding these crowns is shown at *K* in Fig. 11; it consists of an ordinary spring collet, bored out in the front end to receive a fiber "bushing" which is cupped out to suit the crown. This fiber bushing allows the knurling on the crown to sink into it, thus holding it securely while being counterbored, drilled and tapped. Except for the addition of the fiber bushing this spring collet is similar to those previously described, being provided with a spring ejector.

In Fig. 12 is shown another snake-shaped attachment, which is used for handling a collar stud. The slide *B* is fastened to the bracket *A* by U-shaped braces *C*. The work is carried from the slide to the chuck by means of a carrier *D*, similar in construction to that shown in Fig. 5. The spring collet used for holding this piece is similar in construction to those previously shown, and the work is inserted by a spring plunger *E* held in the turret. Attachments of this type are bent to an included angle of 40 degrees, which has been found to give the best results for feeding the parts to the chuck.

Semi-automatic Magazine Attachment

The magazine attachment shown in Fig. 13 is used for feeding the blanks from which the barrels for watch springs are made, to the chuck. A watch spring barrel which has been completely machined is shown at *P* in Fig. 9, and also at *A* in Fig. 18. The teeth are cut on this barrel in an automatic gear cutter. This magazine attachment, which is fastened to the bracket on the No. 0 Brown & Sharpe automatic screw machine, consists of a rotating wheel held on a spindle and enclosed in the casing *A*.

The construction of this attachment is more clearly shown in Fig. 14, to which reference should now be made. The wheel *B* is recessed to form a pocket or magazine for the blanks, and is provided with slots in which the blanks fit. The blanks are inserted in the attachment through the slot *C*, which passes down into the pocket *D* of the rotating wheel. The wheel is driven from a pulley *E*, located on the front cam-shaft (see Fig. 13) by a belt running on the pulley *F* keyed to the wheel spindle. An idler pulley *G* is furnished to change the tension of the belt. As the pulleys *E* and *F* are of the same diameter, the wheel *B* rotates at the same speed as the front cam-shaft. The blanks, when carried around by the wheel *B*, drop into the slide *H* and from there into a pocket in the bushing held in the carrier *I*.

On account of the type of tools shown in Fig. 13, which are used in machining the spring barrel, and the shape of the carrier, it is necessary to increase the actual throw of the ordinary cross-slide, so that the carrier, when it drops back, will allow the tools in the turret to get at the work. The ordinary cross-slide is removed, and a slide *J*, which is shown more clearly in Fig. 15, is substituted. Referring to Fig. 15, it will be seen that slide *A* is provided with a dovetailed slot

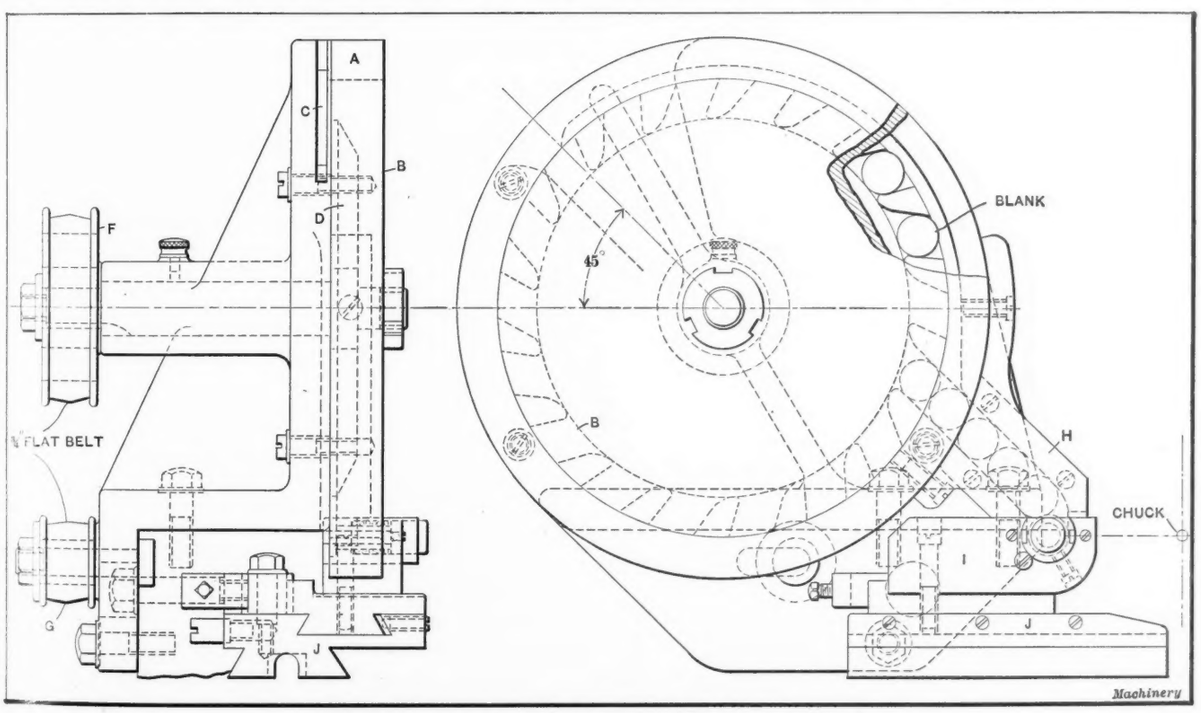


Fig. 14. Assembly Views of Magazine Attachment shown in Fig. 13

in its top face, in which the auxiliary slide *B* works. Attached to the machine by a shoulder screw *C*, fitting in an elongated hole in the bracket *F*, is a rack *D*, that meshes with a pinion *E* held to the lower slide *A* by a screw as shown. Pinion *E* meshes with teeth cut in the auxiliary or top slide *B*.

In operation, as the cam on the front cam-shaft advances the lower slide *A*, the pinion *E* is rotated, this action carrying forward the auxiliary slide *B*, and increasing the throw of the cross-slide. The rack *D* is formed into an L-shape in the rear end, and a set-screw, fitted into it and butting against

the bracket, is used for changing the position of the rack relative to the cross-slide.

The work carrier *I*, Fig. 13, which is shown more clearly in Fig. 16, consists of a block *A* counterbored to receive a bushing *B;* the bushing is also counterbored to receive a spring plunger *C* and cut out to fit the spring fingers *E*. The fingers are made from spring-tempered sheet steel, and fastened by flat-head screws to plugs *F*, which are held in drilled holes

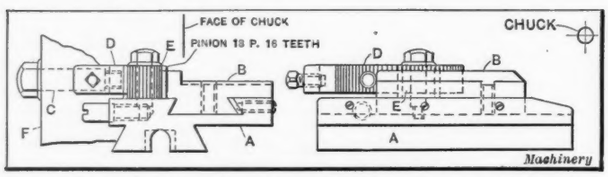


Fig. 15. Double-throw Front Cross-slide for the Magazine Attachment shown in Figs. 13 and 14

in the carrier block *A*, and retained by means of headless screws, as shown. The spring plunger *C* is retained in the bushing *B* by means of a pin driven into the bushing and fitting a terminated slot in the plunger. The bushing *B* is free to slide in the carrier block, and is held back by means of a coil spring *G* bearing against a pin driven into the bushing. The bushing is located in its "back" position by a headless screw acting as a stop for the pin which is driven into the bushing. It is also prevented from rotating by means of a screw *H* turned down on the end to fit a slot in the bushing.

In operation, as the blank comes down the slide, it is deposited in the bushing *B*. The cross-slide then advances and brings the blank in line with the hole in the chuck. When in this position the turret is advanced, and the stop *K* (see Fig. 13) pushes the spring plunger *C* forward, forcing the blank out from the fingers and depositing it in the chuck. It will

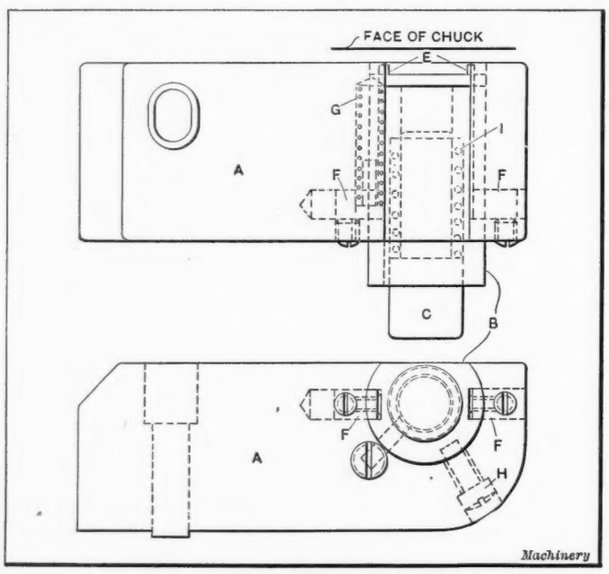


Fig. 16. Work-inserter used in Connection with the Magazine Attachment shown in Figs. 13 and 14

be noticed that the spring *I*, operating the spring plunger *C*, is made much heavier than the spring used for holding back the bushing *B*. The object of this is to insure that the bushing will be brought up close to the face of the chuck before the plunger forces the blank out of the spring fingers.

These spring barrels are difficult to hold, as can be seen by referring to Fig. 18. The part not cut down with the circular form tool is only 0.034 inch wide, which means that only about 0.025 inch can be used for gripping purposes, as it will require from 0.005 to 0.010 inch for clearance. It would be difficult to hold this blank rigidly and true in an ordinary counterbored spring chuck, owing to the fact that a recess would have to be made at the shoulder in the chuck which would reduce the gripping portion.

The manner in which these blanks are held is interesting and is clearly shown in Fig. 17. A special threaded cap *A* is made to fit over the nose of the spindle, and is provided with grooves in which a spider *B* is held to it by screws. This spider is made from tool steel, hardened and ground on both faces. The cap is also hardened and ground on the face bearing against the nose of the spindle and in the slots. The spring collet *C* projects past the face of the spider about 0.028 inch, and is cut out to fit the arms of the spider. The hole in the chuck is serrated to hold the blank more securely.

The tools used for performing the operations on this spring barrel are shown in Fig. 13, where *K* is the pusher which forces the piece out of the carrier into the chuck; *L*, a combination drill and countersink; *M*, a roughing recessing tool; *N*, a second roughing recessing tool; *O*, a finishing recessing tool; and *P*, a reamer holder. The cams used in making this blank are shown in Fig. 18 where the uses of the various lobes are clearly indicated. It might here be mentioned that the making of this spring barrel presents an unusual difficulty in

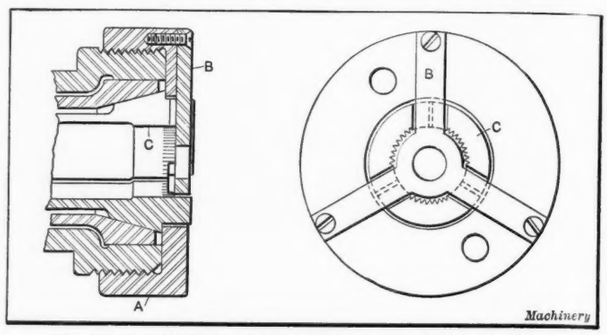


Fig. 17. Special Spring Collet used in Holding the Blank for the Watch-spring Barrel

producing a wall which will be of an even thickness and not cupped. This is accomplished by using a recessing tool for facing, instead of counterboring with a counterbore held in the turret. The application of recessing tools to work of this class was described in an article which appeared in the November, 1910, number of MACHINERY, entitled "Internal Cutting Tools." Here the proportion of the thickness of the wall to

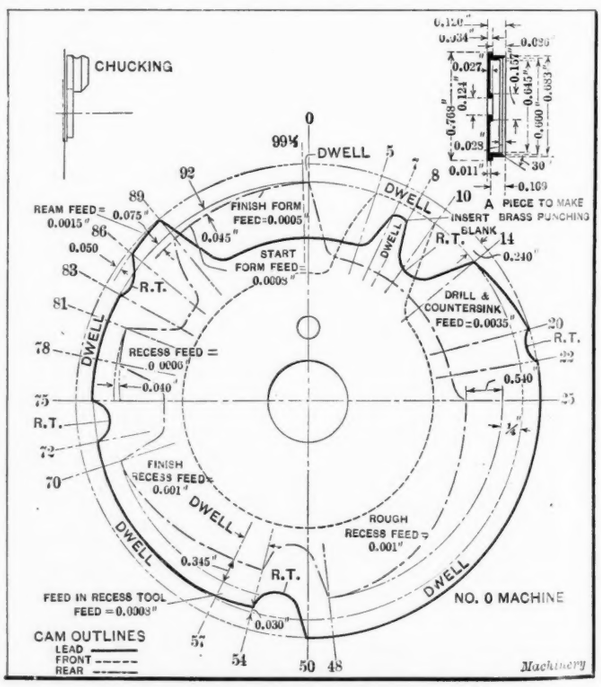


Fig. 18. Cross-slide and Turret Cams used in Producing the Watch-spring Barrel

the diameter, for facing operations, and the feeds to be used, were given.

The order of operations for piece *A*, Fig. 18, is as follows:

Order of Operations	Revolutions	Hundredths
Open chuck	24	2
Eject piece with feeding finger	30	2½
Clearance	6	½
Bring up carrier on front cross-slide	(48)	(4)
Hold carrier in line with chuck	60	5
Insert piece with inserting tool	(30)	(2½)
Dwell with inserting tool	(12)	(1)

Close chuck	(24)	(2)
Clearance	6	½
Revolve turret	42	3½
Drill and countersink, 0.240 inch rise at 0.0035 inch feed	72	6
Revolve turret	24	2
Clearance to place recessing tool in position	12	1
Advance rear cross-slide	24	2
Rough recess, 0.540 inch rise at 0.001 inch feed with L. H. swing tool	276	23
Clearance to drop back pusher on cross-slide	24	2
Revolve turret and clear	48	4
Advance recessing tool and feed in for cut 0.030 inch rise at 0.0008 inch feed	36	3
Dwell with rising block on cross-slide	(36)	(3)
Advance pusher on cross-slide, 0.345 inch rise at 0.001 inch feed	156	13
Clearance to drop back pusher on cross-slide	24	2
Revolve turret	36	3
Bring recessing tool into position	36	3
Advance pusher on cross-slide, 0.040 inch rise at 0.0006 inch feed	36	3
Clearance to drop back pusher on cross-slide	24	2
Revolve turret	36	3
Ream, 0.050 inch rise at 0.0015 inch feed	36	3
Start forming with circular tool, 0.030 inch rise at 0.0008 inch feed	36	3
Finish form, 0.045 inch rise at 0.0005 inch feed dwell 0.050	96	8
Total	1200	100

This article completes the extensive series, which have appeared in MACHINERY from June, 1909, up to the present time on the Brown & Sharpe automatic screw machines. Back numbers of MACHINERY containing all of these articles* cannot be supplied, but the complete series will be incorporated in MACHINERY'S Reference Books, in the near future.

In bringing this series of articles to a close, the writer wishes to express his gratitude to the Brown & Sharpe Mfg. Co., who has very carefully gone over all manuscripts which were submitted. This company has also been very liberal in supplying us with drawings and photographs, for illustrating the machines, tools, and other equipments.

* * *

HOLDING WORK FOR GRINDING

The accompanying illustrations show three methods of holding work that are employed in the Stevens-Duryea factory in Chicopee Falls, Mass. Fig. 1 illustrates a chucking fixture for use in the bench grinding machine for holding small disks

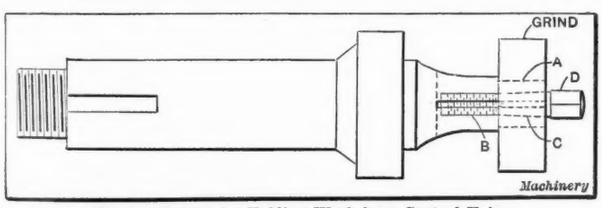


Fig. 1. Fixture for Holding Work by a Central Hole

that must be ground with their peripheries concentric with the central hole. This fixture consists of a shank that fits the spindle of the bench grinding machine. The outer end of the fixture has been turned at *A* to fit the bore of the hole of the piece to be ground. In the center of this turned portion a hole *B* is drilled and tapped. The outer end, *C*, is slightly tapered. Set-screw *D* is made with a tapered section to fit the tapered hole, and, after splitting the end of the fixture with two slots at right angles to each other, the fixture is ready for use. When the pieces that are to be ground are put in place and the set-screw *D* is tightened, the contact of the tapered section of the screw with the tapered hole within the piece to be ground, opens the fixture so that it grips the work tightly and it is certain that the grinding will be concentric with the central hole.

In Fig. 2 is illustrated another fixture for use in the bench grinding machine. The working end of this fixture consists of a part *A* recessed to accommodate the work *B*. The work is held in the fixture by means of two screws *C* and a washer *D*, after which the conical recess is ground in the edge. One

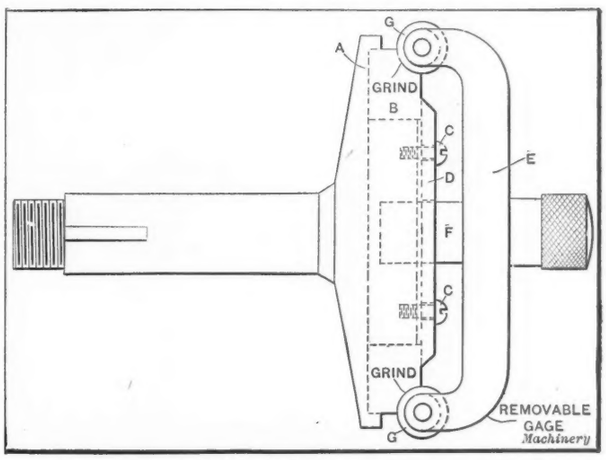


Fig. 2. Fixture for Holding Ball Races for Grinding, and Gage for Testing Work

of the interesting parts of this fixture and work is the method used in checking the grinding. This is done by means of gage *E*. The central plug *F* of gage *E* is made to fit a hole in the fixture, which is ground accurately to the same size as the stud. At the two extremities of gage *E* two steel disks *G* that have been beveled to a knife edge are mounted. By means of this fixture the shape of the ground portion may be checked as well as the overall diameter and the concentricity of the grinding with the bore.

A somewhat different proposition is illustrated in Figs. 3, 4, and 5. Fig. 3 illustrates the piece that must be ground. This piece, it will be noticed, has a hole crosswise of the cylindrical part. The problem is to grind this cylindrical part exactly true with the hole; that is to say, the distances from the center of this hole to the outside of the piece must be

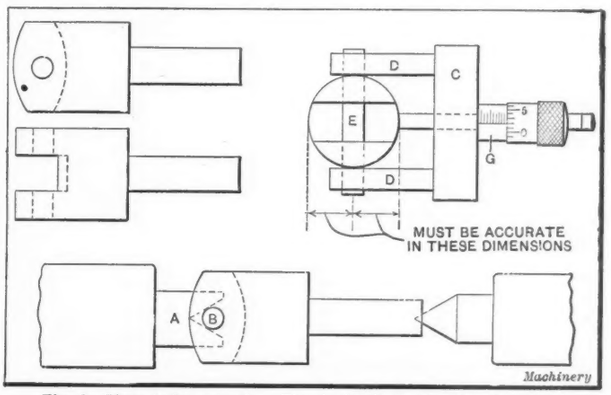


Fig. 3. Piece to be ground. Fig. 4. Method of Testing Accuracy of Grinding. Fig. 5. Method of Holding Work

exactly equal and accurate as to size. This point can be best illustrated by referring to Fig. 4, in which the dimensions that must be accurate are noted. The method used in holding this work for grinding is illustrated in Fig. 5 and consists essentially of a stud *A* whose end is milled with a V-slot that is exactly in the center of the stud. The other end of the work is held in the usual manner by the tail center of the grinding machine. Fig. 4 illustrates the method used in checking the accuracy of this grinding. This gaging fixture consists of a bar *C*, having two arms *D* that are drilled and reamed to receive the pin *E*, which, in turn, may be slipped through the holes of the piece and the holes of these arms *D*. The measuring part of the gage consists of a micrometer head *G* that is mounted in the center of bar *C*. By means of this micrometer head the distances from the center of the hole to the outside of the work in either direction may be readily and accurately measured.

C. L. L.

* The titles and dates of publication of the complete series of articles on the Brown & Sharpe automatic screw machines are: "Magazine Attachments—1," February, 1912; "Milling Cross-Drilling and Burring Attachments—1-2-3-4," September to December, 1911; "Thread Rolling," August, 1911, engineering edition; "Knurls and Knurling Operations," July, 1911; "External Cutting Tools—1-2-3-4-5," January (except May) to June, 1911; "Internal Cutting Tools—1-2-3," September to November, 1910; "Designing Screw Machine Tools and Cams," August, 1910; "Threading Operations—1-2," June to July, 1910; "Circular Form and Cut-off Tools—1-2," March to April, 1910; "Knurls and Knurling Operations—1-2," June to July, 1909, engineering edition.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY.

A THREE-SPINDLE DRILLING ATTACHMENT

As the demand for the product of a manufacturing concern increases, new tools must be designed to increase the output. The company with which I am employed makes a large number of cast-brass rings of different diameters and thicknesses.

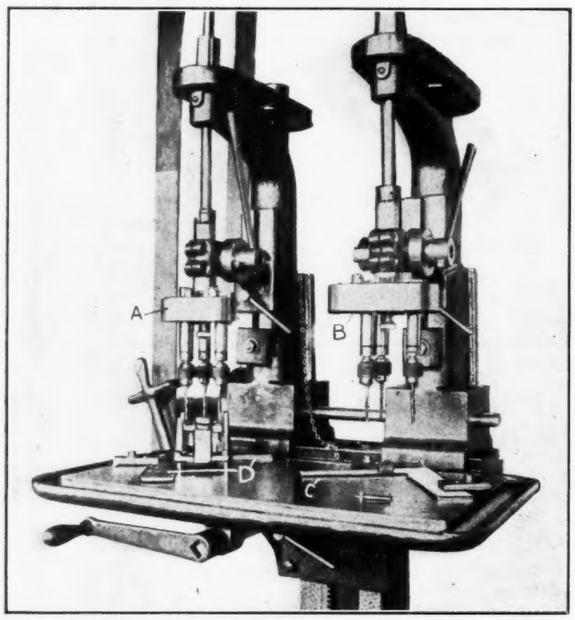


Fig. 1. Drill Press equipped with Two Three-spindle Drilling Attachments

These are attached to plates with three fillister-head screws. The three-spindle drilling attachments, shown in Fig. 1, were made by the writer to drill the three holes in these plates and the three tapped holes in the sides of the brass rings. The diameter of the hole circle is larger on one side of the ring than on the other, thus requiring two drilling attachments.

Fig. 1 shows a drill press equipped with the two attachments *A* and *B*, and also the right-angle plates *C* and *D*, made from 3/16-inch steel, which are clamped to the table to locate the bushings in the drill jig quickly in line with the drills. The attachment *A* will drill three equally spaced holes in any circle from 2 5/8 inches in diameter up to and including 4 7/16 inches in diameter, while the attachment *B* will handle hole circles varying from 3 3/16 inches up to and including 5 1/2 inches in diameter.

At *A* in Fig. 2 is shown a view of one of these attachments looking directly at the chucks, and by close inspection it will be seen that teeth are cut on part of the circumference of the spindle members. There are 24 teeth, 24 pitch, cut in each spindle member in such a position that when the central knob *B* is revolved, the spindles are moved in toward the center of the attachment. The chuck spindle gear has 15 teeth and just clears the driving gear having 53 teeth, which is fastened

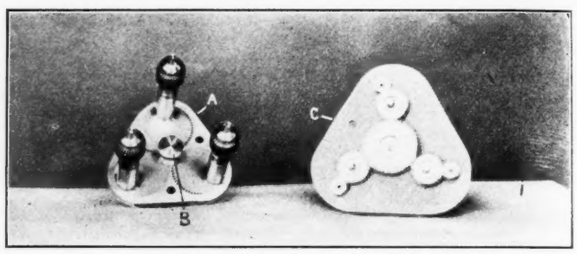


Fig. 2. Views looking directly on the Chuck and Gears

to the drill press spindle. The arrangement of the gears can be seen at *C* in Fig. 2, and also in Fig. 3. All gears are cut 24 pitch.

The feed or spindle quills were removed from the drill press, and a special type attached to the fixture as shown at *A* in Fig. 3; then the two drilling attachments *A* and *B* shown in Fig. 1 were put in place, making the machine a permanent multi-spindle drill press. The attachments are made of steel except the quill *A*, Fig. 3, which is made of brass; provision is made to save the expensive parts from excessive wear by making the bushings in the chuck spindle member and the intermediate gear of phosphor-bronze. The ⅜-inch cap-screws *B* pass through the two plates *C* and *D* and the ½-inch steel

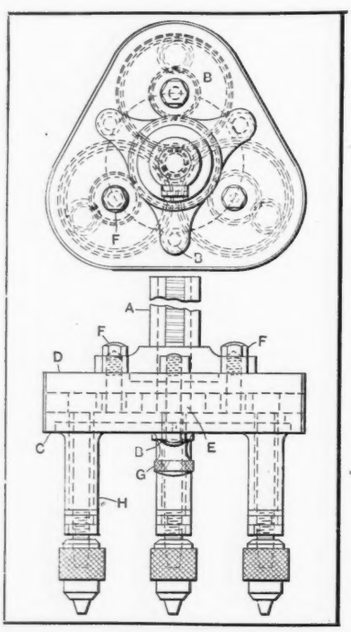


Fig. 3. Elevation and Plan Views of the Three-spindle Drilling Attachment

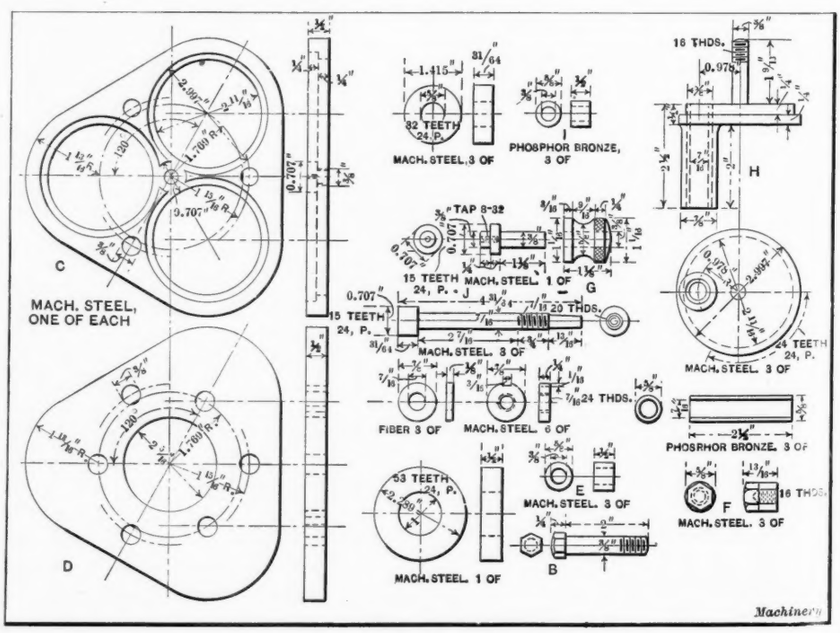


Fig. 4. Details of Three-spindle Drilling Attachment

bushings *E*, which are located between the plates. The cap-screws are also fastened into the three projections on the quill *A*, thus holding the three members firmly together.

To change the position of the spindles the three hexagon blind nuts *F* are loosened, and the central knob *G* is turned

in the required direction, moving the spindles *H* to the proper diameter, so that the drills will line up with the bushings in the drill jig. When the nuts *F* are tightened, the spindle member is drawn up against a shoulder in the bottom plate *C*, and the phosphor-bronze bushings *I*, see Fig. 4, in the intermediate gear are drawn up against the top-plate *D*, thereby locking each spindle firmly.

The details of this three-spindle drilling attachment are shown in Fig. 4, similar parts in Figs. 3 and 4 bearing the same reference letters. The central knob *G* is forced onto the ⅜-inch end of the stud *J* after the teeth are cut, and is held in place in the bottom of the plate *C* by a tight fitting screw and washer, which projects into a recess turned in the driving gear on the main spindle. The construction of the other parts are clearly indicated in Fig. 4 so that further references are not necessary.

The fact that three of these drilling attachments have been made speaks well for their efficiency. Besides using these attachments for drilling three holes they are also used for drilling two holes where the distance between centers or the distance across the chord with a 6-inch hole circle comes within the range of the attachments. The capacity of the chucks is from the smallest size drill up to and including a No. 1 drill. The spindles rotate at 1400 R.P.M., and provision is made for oiling the spindles by drilling oil holes in the top plate *D* and tapping it for flat-head screws. Oil grooves are also cut in the drilling spindles, so they are furnished at all times with a copious supply of lubricant. The gears also are well lubricated.

Dorchester, Mass. ALBERT C. SAWYER

TWISTING IRON ON THE BULLDOZER

When it is desired to twist one or both ends of a rectangular bar which is considerably wider than it is thick, the twisting can be done on a bulldozer without the aid of any complicated mechanism. The twisting device may also be used in connection with a former, for bending the bar in the direction of its greatest width. The method employed is illustrated in Fig. 1.

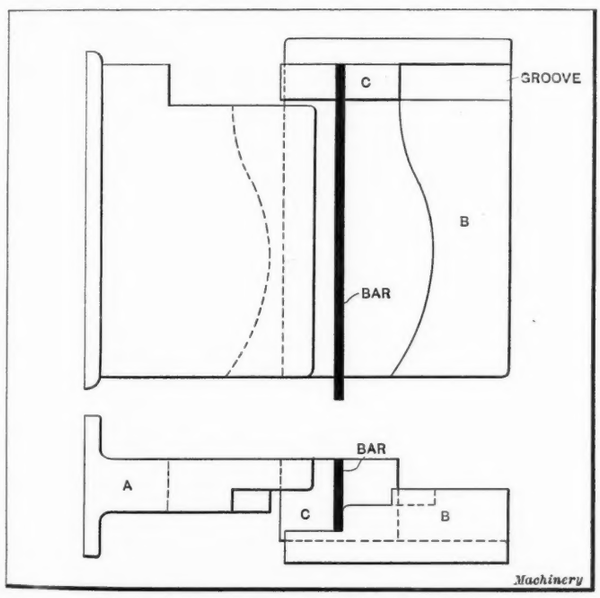


Fig. 1. Formers for Twisting Iron on the Bulldozer

The casting *A* is attached to the crosshead of a bulldozer, and corresponds to the movable die in the ordinary former, while the casting *B* corresponds to the stationary die. It will be seen that if the bar, which is shown standing on edge, is firmly held in this position at one end, it will be twisted when the dies come together. To hold the end of the bar in position, a block *C* is used, provided with a slot to fit the bar. It is evident that this block *C* must move forward with the movable die; otherwise the bar would be distorted at the point of the bend. This is easily done by cutting a groove in the stationary die, into which the block will slide. The curved lines on the formers represent the shape to which the bar is to be bent.

In Fig. 2 is shown some of the work which may be accomplished by formers of this kind. *C* shows a bar which is both twisted and bent, and *B* shows a bar twisted at both ends. Should it be desired to bring the twisted end on either side of the center of the straight portion of the bar, and have

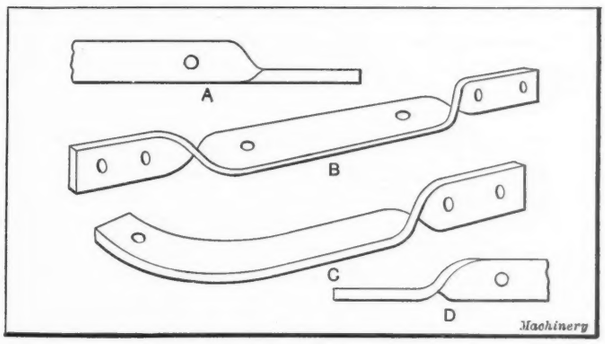


Fig. 2. Examples of Twisted Iron Bars

the flat surfaces at right angles to each other, as shown at *A* and *D*, this is easily done by lengthening or shortening the projection on the movable die, which bears against the block.

By the additional provision of a link connecting the block *C* to the movable die *A*, Fig. 1, the block can be brought back to the first position with the backward stroke of the machine. If the block is short, it will be necessary to use a guide or some other means of preventing it from tipping up as the bar twists.

W. L. B.

DIAGRAM OF EFFICIENCIES OF WORMS AND SCREWS

The accompanying diagram shows at a glance the percentage of efficiency of worms and screws when the ratio between the lead of the screw or worm thread and the pitch diameter is known. The inexperienced designer is apt to overlook the question of efficiency, but unless this is considered, it is possible that an apparently ample leverage will be so reduced by the inefficiency of the screw that hand adjustment will be difficult or power adjustment subject to severe wear. The diagram given is similar to one published in a book entitled "Worm and Spiral Gearing," by Frederick A. Halsey, but is easier to apply on account of the introduction of the factor of the ratio of lead to pitch diameter in place of the angle of the thread.

It will be seen that two curves are given, one for the efficiency of the worm alone and one for the efficiency of worm and step. The first curve is used in cases where the end thrust is taken by a ball bearing, while the second curve is

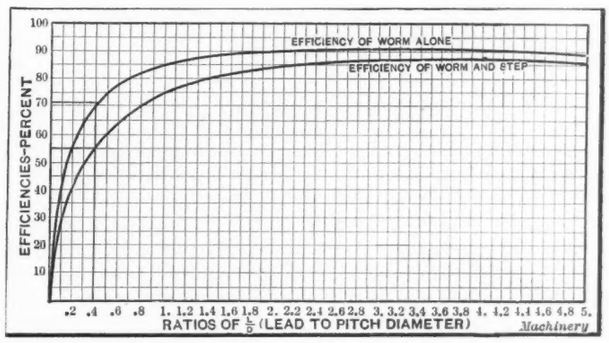


Diagram of Efficiencies of Worms and Screws

used when the end thrust is taken by an ordinary washer, causing friction at the end of the worm. The formulas upon which these curves are based are as follows:

$$\text{Efficiency of worm alone} = \frac{\tan \alpha \ (1 - f \tan \alpha)}{\tan \alpha + f}$$

$$\text{Efficiency of worm and step} = \frac{\tan \alpha \,(1 - f \tan \alpha)}{\tan \alpha + 2f}$$

In these formulas α = angle of thread.

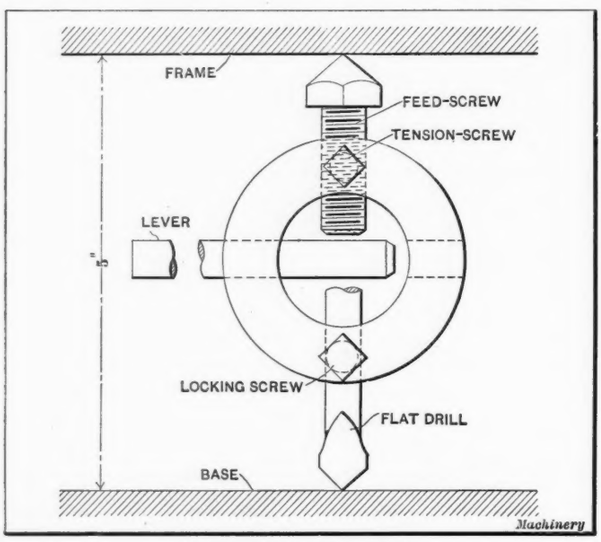
f = coefficient of friction, assumed as equal to 0.05.

As an example of the use of the diagram, find the efficiency of a worm with ½-inch lead, single thread, and 1¼-pitch diameter; the ratio of lead to pitch diameter is $0.5 \div 1.25 = 0.4$. From the curves we find that the efficiency is 71 per cent for the worm alone, and 55 per cent for the worm and step.

Scottdale, Pa. F. D. BUFFUM

AN IMPROVISED DRILL AND FEED

It was at one time necessary to drill two 1/2-inch holes in the base of a machine where there was only 5 inches of space available, as shown in the accompanying illustration. Our shortest ratchet drill was 7 inches over all, so that it could not be used. The job was in a hurry, so the man doing it picked up an old collar, drilled a few holes in it, arranged the



An Improvised Drill and Feed

two set-screws as shown, the lower one bearing against a flat spot on the drill, and the upper one screwed against a copper plug and the feed-screw. The latter set-screw provided a tension to prevent the screw from feeding too fast. A piece of 7/16-inch iron was then applied as a lever to turn the drilling device, and a wrench was used to work the feed-screw, which was a common set-screw with the head ground to a sharp point.

Newark, N. J. H. E. WOOD

[The tension-screw was unnecessary if the feed-screw was properly pointed on the outer end. The resistance to turning of the screw in its nut, under ordinary conditions, is always greater than that of a pivot of smaller mean diameter when both are carrying the same load.—EDITOR.]

STRAIGHTENING SHAFTING

There is one operation in machine shop practice to which even the best mechanics look forward with dread, *i. e.*, straightening a screw or shaft. This is due largely to the lack of understanding of the principles of straightening on the part of the majority of mechanics. While some shafts require more time to straighten than others, the operation becomes comparatively simple if approached with the proper understanding and appliances.

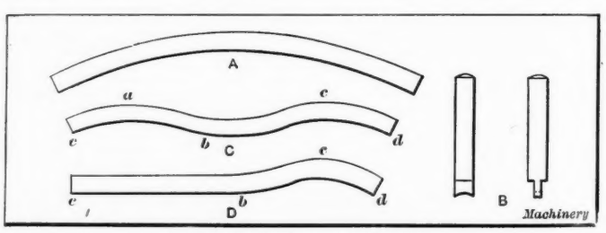
Every shop worthy of the name should have some good straightening devices. These, as a rule, can be made cheaply and are so simple that they need not be discussed. If nothing else is at hand an I-beam, a couple of V-blocks and a jack-screw serve the purpose, and these are especially good for straightening long shafting. A shaft becomes bent through various causes, *e. g.*, it may be strained beyond its elastic limit, as when overloaded; or it may be subjected to too much heat, causing unequal internal strains, as when taking a cut over a piece of rough iron or steel, or when keyseating a shaft especially when it is made from commercial cold-rolled steel.

By referring to the accompanying illustration it will be seen that the shaft which is shown at *A* has a single bend and is considerably longer on the top side than on the bottom. In order to produce this effect the fibers on one side were stretched and those on the other, compressed. Now to bring the shaft back to its normal state, this condition of the fibers must be reversed.

If through some accident a shaft is strained beyond its elastic limit it should never be used for the same purpose even though it be made to run practically true, unless the load is not excessive in proportion to its size. A shaft once distorted will never have the same resisting qualities that it had before the accident. Shafts running at a high rate of speed having keyways cut between the journals, even though splined on both sides, give trouble on account of the vibration caused by the shaft being out of balance. This can be avoided either by designing the shaft stronger than necessary, to give it additional stiffness, or by cutting a slot in each side one-half the proper width for that size of shaft. For instance, a ½-inch keyway being standard for a 2-inch shaft, cut a ¼-inch slot on each side of the shaft in diametrically opposite positions. This leaves the shaft strong and easy to straighten.

Shafts which have to withstand suddenly applied loads, such as the crankshaft of a gasoline engine, can be made to hold the flywheel so that it will not loosen by making the keyway wider than the standard width and having the key a good fit sideways. Crankshafts turned by the ordinary method in the lathe will invariably be found to spring slightly. This is caused by clamping too tightly the screw that is placed between the arms when turning the journals, so that when the screw is removed, the arms spring in, causing the shaft to bend. To remedy this, place a small jack-screw between the arms and by repeated trials, applying a little more pressure each time, spring the arms outward until the journals run true.

Shafting, arbors, lead-screws, etc., are straightened in three different ways. First by means of hammer blows, second, by steady pressure, and, third, by peening. To straighten a shaft by the first method support it upon its ends or between the ends, as the case may be, and strike it with a hand hammer or sledge, depending on the size of the shaft, upon the high or tension side. This forces the long side inward and the



Methods of Straightening Shafting

short side outward. The second method consists in supporting the shaft near its ends or between centers in the lathe (this is not good for the lathe) and applying pressure upon the high side by means of a lever or screw. The third method is a combination of the first and second and consists in stretching the low or compression side by tapping with a hammer at the same time that pressure is applied to the high side.

At *B* in the accompanying illustration is shown a tool for straightening shafting having a square thread cut on it. This tool can be made from an old chisel and will not mar the threads. It is placed between the threads, and while pressure is being applied underneath the shaft, the top of the tool is struck with a hammer. A shaft which is badly bent should be heated and straightened as true as possible. If worked when cold, the shaft will crystallize and break easily.

To straighten the shaft shown at *C*, center each end true, or, if it is too long to go between the centers of the lathe, rest each end upon V-blocks. Now rotate the shaft, and with a piece of chalk find the high spots which would be at *a* and *c*. If the shaft is rough and not very large, it can be quickly straightened by placing it upon an anvil or hollow block and

striking the high spots with a hammer. If the shaft is finished—having a smooth surface—commence at one end, the left-hand end, for example, and work towards the other end. To proceed, fasten end *e* and part *b* with the high side down, apply pressure at *a* and tap the opposite or low side with a hammer, care being taken to use some soft metal, such as sheet copper on both sides to prevent bruising the shaft. A point which should not be overlooked is this: While straightening a shaft by any of the methods given, the pressure or blows should be gradually increased. If it is found upon trial that the shaft is still sprung in the place where the pressure has been applied, the pressure has not been enough. If unfamiliar with the kind of steel, use very little pressure at the first trial.

If the part of the shaft between *e* and *b* shown at *C* is straight, as shown at *D*, fasten the shaft at *b* and *d* with the side *c* down, and apply pressure at *c*, proceeding in the same manner as before described until that part is straight. If the shaft is made from cold-rolled steel or common machine steel, it will be found that some of the bend has returned in the other end of the shaft previously straightened. In this case go over the shaft from the right-hand end in the same manner, and with a little patience and judgment it will be found that what was at first considered drudgery will become an interesting task.

JOHN W. BRANDLE

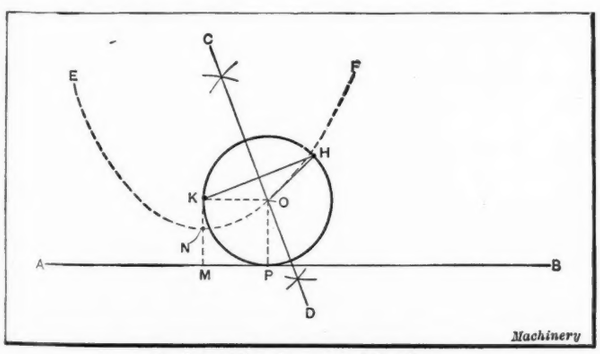
Nashville, Tenn.

A GEOMETRICAL PROBLEM

The following geometrical problem and its solution will probably be of considerable interest to the readers of MACHINERY. If this problem were given unaccompanied by its solution, it is probable that many good mathematicians would spend some time trying to obtain a solution. As far as the writer knows, this problem and its solution are original with him.

Given a straight line *AB* and any two points without it, but on the same side of it, as *K* and *H*. Required a circle passing through *K* and *H* and tangent to *AB*.

Draw *KH*, and bisect it by line *CD;* then the center of the required circle will be somewhere on line *CD*. From *K* draw a line *KM* perpendicular to *AB*; bisect line *KM* as at *N*. With *K* as the focus and *A B* as the directrix, construct a parabola



An Interesting Geometrical Problem

ENF. The point where the parabola intersects line *CD* is the center of the required circle.

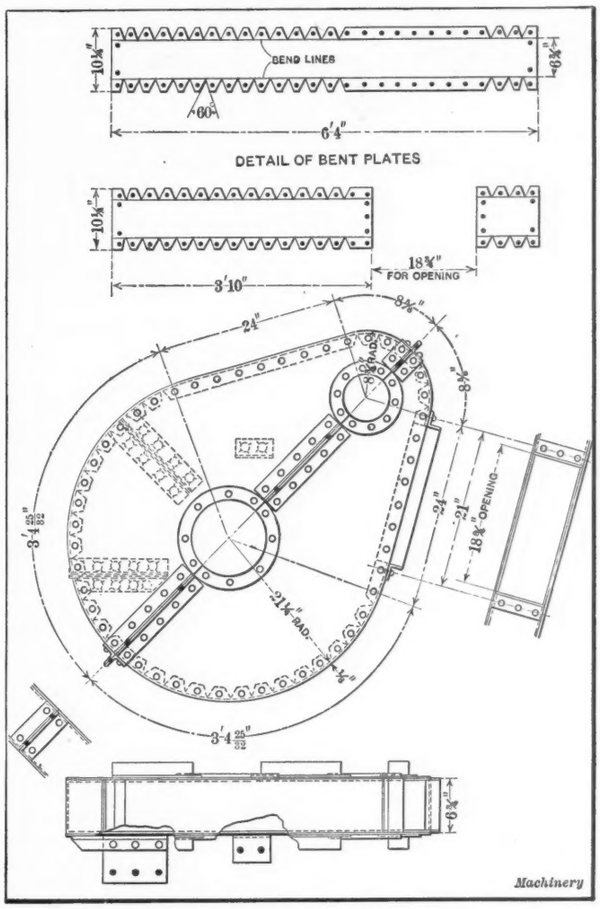
The proof is very simple. In any parabola, any point on its curve is always at an equal distance from its focus and its directrix, hence, $KO = OP$; but *KO* also equals *HO*; hence *O* is the center of a circle which satisfies the given conditions.

Chicago, Ill. C. W. HINMAN

SHEET-STEEL GEAR CASES

All gears should be provided with cases that will permit them to run in a bath of oil or grease. We provide carefully for oiling all bearings, slides, etc. Why should we then expect gears to run with haphazard lubrication? A gear case prevents spattering and waste of the lubricant, and it deadens the noise. It also keeps dust out of the teeth, and most important of all, it prevents accidents more efficiently than any guard which does not entirely encase the gears. The day is rapidly approaching when the unguarded or unencased gear will be a thing of the past, and purchasers of machinery ought always to specify gear cases when ordering new machines. It will save money in the end, in addition to all the other benefits mentioned.

The gear case construction shown in the accompanying engraving may be of interest. The rigidity of such cases is surprising and their cost is very small; moreover, they weigh but a small fraction of what a cast-iron case would weigh in any given instance. If they are bent, they can be easily repaired, and they are hardly liable to any more serious injury. The accompanying engraving shows the construction of the



General Design of a Sheet-steel Gear Case

gear case somewhat in detail, but an ordinary sheet metal worker has made at least one hundred of these gear cases, nearly all of different sizes, with no information except the sizes of the gears and shafts. The case should fit over the hub of the gear, or over the box, instead of over the shaft, wherever this is possible. A large hand-hole is always a convenience, and there should be an inch or so of clearance between the teeth and the cases in the radial direction. Even in cramped quarters, inside clearance is sometimes of more importance than clearance on the outside, and it leaves room for various articles that might fall into the case and prevents them from being picked up by the teeth. There is no comparison in cost between the construction shown and one with bent corner angles. There is no trouble about making this case tight enough to hold grease or heavy oils.

Scottdale, Pa. F. D. BUFFUM

[The opening in the case should, of course, be in an upper side and not in a lower side, as erroneously shown in the engraving.—EDITOR.]

COMBINATION BENDING AND TWISTING DIE

Fig. 1 shows a latch for a go-cart which was formed and twisted in the die shown in Fig. 2. This latch is first cut off and formed to the shape shown at *A* in Fig. 1, after which it is placed in the die shown in Fig. 2, and bent and twisted to the final shape shown at *B*.

The lower bending die *A*, Fig. 2, is held in a cast-iron base *B*, and pins *C*, driven into the former, extend down through the base and come in contact with a pressure plate *D* operated by a rubber pad *E*. The top forming die *F* is held by screws and dowels, as shown, to the holder *G*, which has a shank to fit the hole in the ram of the press. This holder *G* is lined up with the base *B* by standards *H*, and holds two pins *I* which oper-

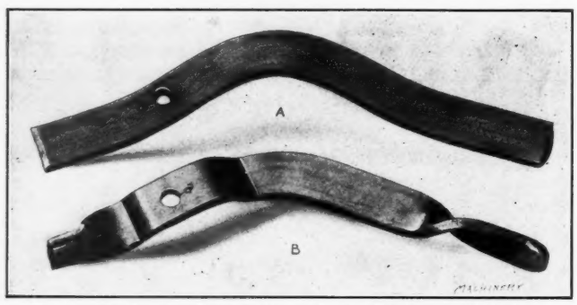


Fig. 1. The Go-cart Latch before and after Bending and Twisting

ate the lower twisting dies *J* and *K*. The twisting dies *J* and *K* correspond in shape to the dies *L* and *M*, which are provided with shanks and are held in the holder *G* by screws and dowels.

The lower twisting dies *J* and *K* are given a slight upward movement by means of the pins *I*, which come in contact on the downward stroke of the ram with fulcrumed levers *N* held on pins *O*. These fulcrumed levers are connected to the twisting dies by pins, as shown more clearly in Fig. 3, where the operation of the twisting dies *K* and *M* is illustrated.

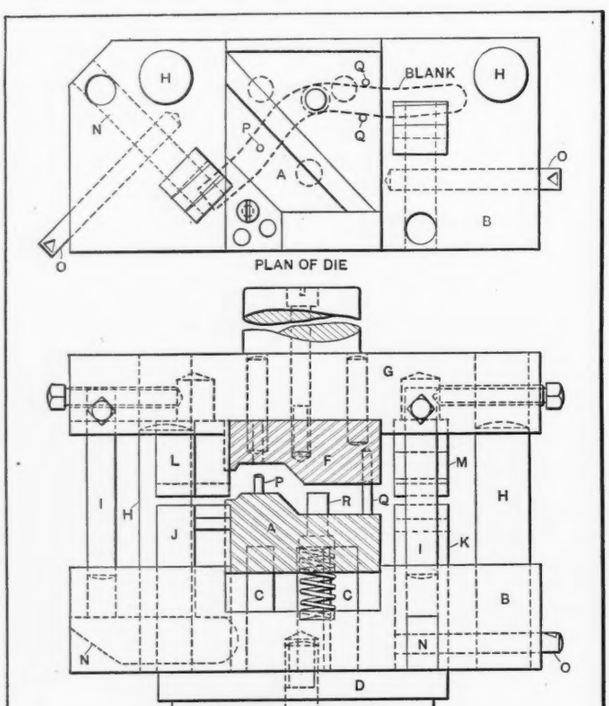


Fig. 2. Elevation and Plan Views of the Combination Bending and Twisting Die

In operation, the blank shown at *A* in Fig. 1 is placed on the lower die *A*, Fig. 2, the hole *a* fitting on the pin *P* and the blank being located between the pins *Q*. A spring plunger *R*, operated as shown in Fig. 2, prevents the blank from dropping down, holding it flush with the highest surface of the lower forming die. As the ram of the press descends, the upper former forces the blank down, bending it to the shape shown at *B* in Fig. 1, and as the ram still continues in its downward movement, the pins *I* operate the lower twisting dies through the levers *N*. The combined action of the upper and lower twisting dies forms both ends of the blank to the shape shown at *B* in Fig. 1. The lower die *A*, while the twisting

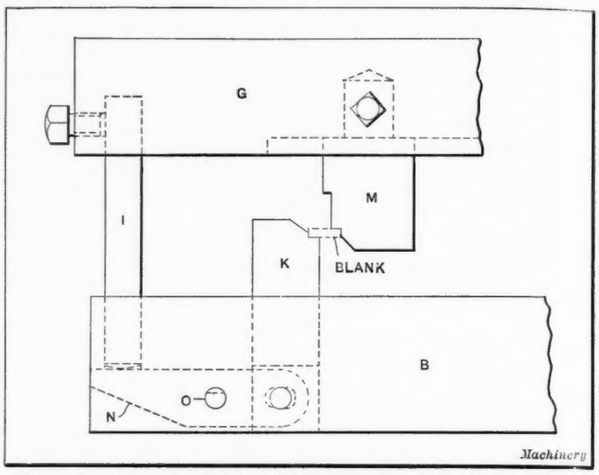


Fig. 3. Part View showing how the Twisting Dies K and M are operated

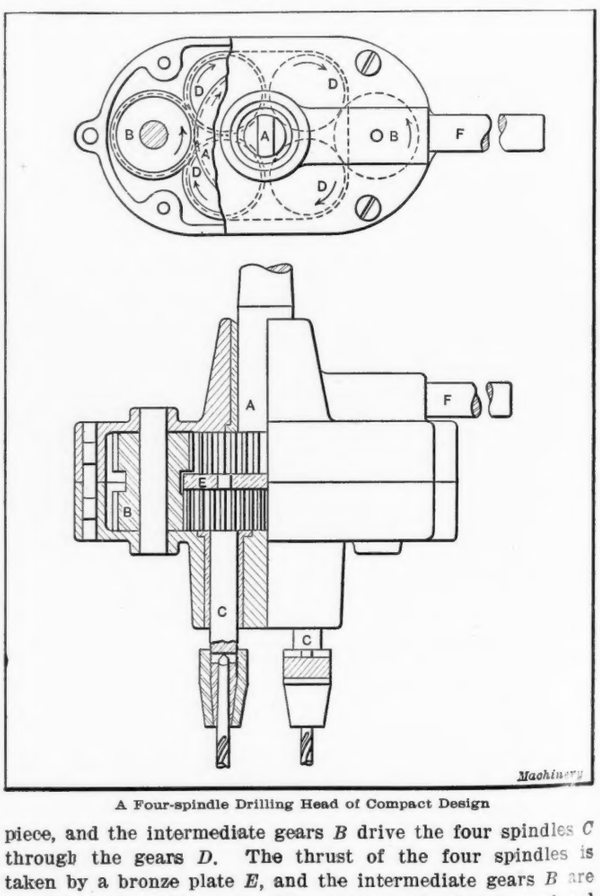
operation is taking place, has been forced down to the lowest point of its travel, compressing the rubber pad *E*, which returns it to its former position when the ram of the press ascends.

F. W. Jonas

Sturgis, Mich.

A FOUR-SPINDLE DRILLING HEAD

Having a large number of pieces to drill, each with four 3/16-inch holes, spaced 1 1/2 inch apart on a square, we designed this fixture to drill the four holes simultaneously. On account of the small space between the gears, and to avoid the necessity of making special left-hand drills, the arrangement of the gears shown in the accompanying illustration was adopted. The driving gear and shank *A* are made in one



A Four-spindle Drilling Head of Compact Design

piece, and the intermediate gears *B* drive the four spindles *C* through the gears *D*. The thrust of the four spindles is taken by a bronze plate *E*, and the intermediate gears *B* are cut out to clear this plate. The whole mechanism is enclosed

University of Iowa 11 MAR 1912

in two cast-iron covers, and is prevented from turning by the handle *F* which comes in contact with the column of the drill press. The intermediate gears *B* run on pins which are driven into one side of the case, and all of the spindles are provided with bronze bushings.

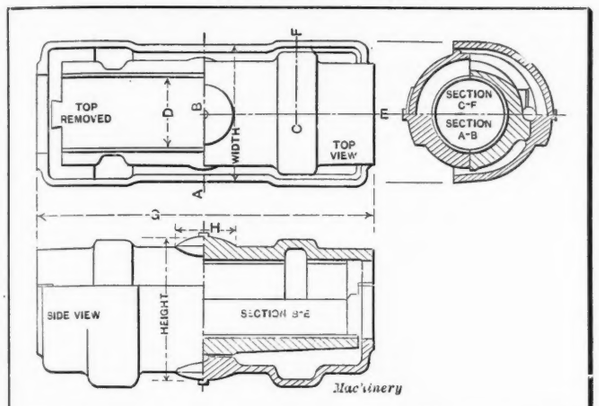
Stamford, Conn. KINGSTON FORBES

RING OR CHAIN OILING SELF-ALIGNING BEARINGS

The illustration shows side, plan and section views of a ring- or chain-oiling self-aligning box that I designed in eighteen standard sizes for 1 3/16-inch to 5 15/16-inch diameter shafts.

The table gives the length of bearing, length over-all, approximate weight complete, diameter of the spherical part *H*

RING OR CHAIN OILING BOXES



Size of shaft D	1 3/16	1 7/16	1 11/16	1 15/16	2 3/16	2 7/16	2 11/16	2 15/16	3 3/16
Length of bearing	6	6	7	8	9	10	11	12	13
Length over-all, G	8	8	9 1/4	10	11 1/4	12 1/4	13 1/4	14 1/4	15 3/8
Height	4	4 1/8	4 3/8	4 7/8	5 1/8	5 3/8	5 5/8	5 3/4	6 3/8
Width	3	3 1/4	3 1/2	3 3/4	4 1/2	4 1/2	4 3/4	5 1/4	5 3/4
Approx. wt., lbs.	11	12	14	20	22	26	30	36	48
Dia. of boss, H	1 1/2	1 3/4	1 3/4	2	2	2 1/4	2 1/2	2 1/2	3
Thickness of babbitt	5/32	5/32	5/32	5/32	3/16	3/16	3/16	3/16	3/16

Size of shaft D	3 7/16	3 11/16	3 15/16	4 3/16	4 7/16	4 11/16	4 15/16	5 7/16	5 15/16
Length of bearing	14	15	16	17	18	19	20	22	24
Length over-all, G	16 3/8	17 1/2	18 1/2	20	20 1/2	22	23 1/2	25	27 1/2
Height	6 3/8	7 1/8	7 1/2	7 3/4	8	8 1/4	8 3/8	9	9 3/8
Width	6 1/2	6 1/2	6 3/4	7	7 1/4	7 3/8	8	8 1/4	8 3/4
Approx. wt., lbs.	60	65	70	75	78	86	95	105	120
Dia. of boss, H	3	3 1/4	3 1/4	3 1/4	3 1/4	3 1/2	3 1/2	3 1/2	3 1/2
Thickness of babbitt	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4

and other data necessary for the patternmaker and machinist.

The advantages of the ring-oiling self-aligning type of bearing should commend it to every designer of machinery, and I hope that these standard sizes may be of as much use to others as they have been to my friends and myself.

San Antonio, Texas. A. W. WINTERBORNE

NEAT'S-FOOT OIL AS A CUTTING LUBRICANT

Some time ago we had a lot of small iron nuts to tap. This job was done by boys in a lathe using taps about 5 inches long made from drill rod. Considerable trouble was experienced with the taps' breaking, and as an experiment we tried neat's-foot oil as a cutting lubricant. This ended the breakage of taps and they lasted until worn out. Since then we have used neat's-foot oil in the threading and difficult forming of steel, and it has always given good results.

We are now broaching soft steel pieces, and using this oil as a lubricant with success. The holes being broached are enclosed on three sides, the fourth side being open. This work has always given trouble because of the seizing of the broach which necessitated sawing the piece in two in order to remove the broach. Since using this oil we have not spoiled a piece, and the holes are smooth and correct to size. While a great many know that neat's-foot oil makes a good, if not the best, belt dressing, I have not met anyone who used it as a cutting oil.

New Haven, Conn. FRANK K. LOVELAND

PHYSICAL HEALTH AND DRAFTING

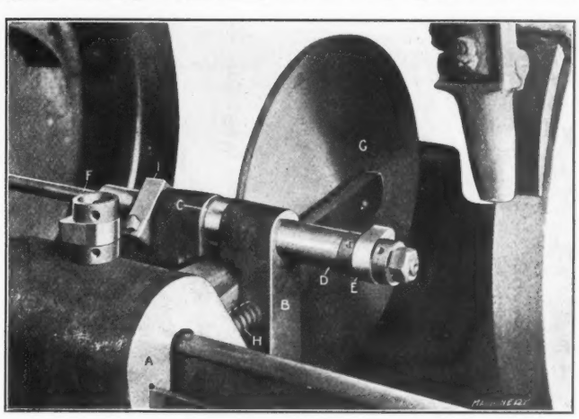
The question of physical health is of prime importance to draftsmen, and it has been freely discussed of late, but it still remains open. We do not all agree with L. R. W. A., in the November number of MACHINERY, in his denunciation of the "apron" type of draftsmen. It is practically, if not absolutely, impossible to avoid pressure on the abdomen in working. You must "get there" and produce, and the only way to reach the top of the board one moment and the bottom the next, is to use the body. There are, of course, extremes in this as in all other cases. I call to mind one "knight" of the board who used his abdomen as a pivot, (he was possessed of a fair-sized bay window) to enable him to roll to the top of the board. This "feat" in time will produce disastrous results—indigestion and its companion ailments. A moderate use of this part of the body, however, can have no very bad effects. If it were possible to avoid this altogether, why does not the instructor show the pupil the "only correct position" to assume when drawing? In teaching penmanship, stress is laid on the importance of proper posture, and why not in drafting? That is the time to correct the evil if it exists, as life-long habits are hard to break.

Exercise seems to me to be the one important factor in a draftsman's health. He needs something to take the kinks out of his system which are acquired in the "daily grind." A few simple bending and breathing exercises practiced morning and night will work wonders. Ventilation is also important. A stuffy steam-heated room is more of a health destroyer than anything else. Right here arises a difficulty: A opens a window and B growls, "Shut that window! Were you brought up in a barn?" That is human nature, but a draftsman should get all the fresh air he possibly can. It seems that a little more attention paid to details would eliminate all of this "slow death" idea and make drafting an attractive proposition, as it should be.

New Britain, Conn. J. M. HENRY

A CAM GRINDING FIXTURE

The accompanying illustration shows a cam grinding fixture applied to a Norton plain grinder. The base *A* of the fixture is clamped to the bed of the grinder, and carries a rocker arm *B*, which is hinged to it. The master cam *C* is keyed to the shaft *D* on which the cam *E* to be ground is held. This shaft is revolved by a flexible coupling *F* driven from the regular driving mechanism, and is held against the center



A Cam Grinding Fixture applied to a Norton Plain Grinding Machine

in the grinding head by a spring located in the shaft. The master cam *C*, when revolved, is kept in contact, by springs *H*, with the roller *G*, which is pivoted to the base *A*. These springs *H*, only one of which is shown, force the master cam against the roller, thus imparting an oscillating movement to the rocker arm, which controls the shape of the cam to be ground. A brake *I* is used to prevent the work from jumping away from the wheel on the relieved side of the master cam. With this attachment, which was designed and built in the apprentice department of the General Electric Co., we are able to make cams at the rate of one every ten minutes to within 0.002 inch of the master cam.

West Lynn, Mass. CHARLES K. TRIPP

REMARKS BY THE ONLOOKER

In reading the interesting article on ball making in the February number of MACHINERY, I recall one of my first jobs in an American shop—the finishing of a number of balls for a floating crane. I was quite proud of my achievement when after much labor the work was done. At noon some of the boys began to caliper the balls, the polish of which was of a considerably higher standard than their uniformity of size, and I suddenly began to lose my pride; in fact, what little remained after they were all calipered, quite disappeared when an old Scotchman said, "Well, my lad, the first one is alike anyway." The present perfection in ball making shows what can be done in the manufacture of great numbers, with proper application of energy and thought.

For years I have had an idea in my mind of some kind of a coating to protect certain parts of a piece when being hardened. Enamelite, as described on page 482, engineering edition, meets with the requirements. Time and time again I have wished for just such a preparation, and it seems to me that it ought to sell like the well-known "hot cakes."

The new design of milling cutter shown by the National Twist Drill & Tool Co., on page 97 of the advertising section, is something that interests me a great deal. It is not an easy thing to combine solidity and simplicity in an inserted tooth milling cutter, and to me it seems that this is almost, as they say down East, "the end of the asking"—just a turned up disk, a few drilled holes, some plain milling, a few pins, and there you are.

If Mr. F. B. Jacobs' article on "Sharpening Milling Cutters" could not only be read, but also acted upon, by those that have to do with the sharpening of these tools, the output of milling machines, I believe, could be increased by 25 per cent. I recall an old man once who, when taking charge of the milling department of a shop, remarked, "Yes, they have got a lot of millers up there that hiccough and grunt the stuff off," and that, I fear, is too often a true description of the way in which milling machines are allowed to do their work.

For years, drill press tables have been weak on account of their overhang, and many a careful mechanic has blocked up the table for heavy drilling or for heavy pieces by means of a screw-jack, or by some other means if no screw-jack was available. To-day this is not often required in modern machines, as drill makers are providing a support as indicated in the Barnes drilling machine, shown on page 480, and in the Taylor & Fenn radial, shown on advertising page 184, which, by the way, is a most convenient tool, although I think it would be an improvement if a slotted tie-rod were provided from the arm to the table. This would stiffen the tool and add but little to the cost. In the Gang radial drill, advertising page 162, a support for the table is also provided, and in some makes of shapers the idea is introduced to advantage. To a very large extent, this stiffening of machine tools is called for by the heavy cuts taken by high-speed steel tools, but the added accuracy of the work produced on solid machines has also acted as an incentive for tool builders to produce something which is not only strong enough, but also "non-vibrating" enough, to produce accurate work. The Lees-Bradner Co. says that "overhanging is a vital error in design," and mechanical designers are beginning to recognize this fact to a marked degree.

To change the subject, let us talk of twist drills. Just look at the row of "maimed soldiers" on advertising page 31. Of course the number of drill presses and collets now in use, scattered all over the world, could not be thrown away or changed without great expense, but the advertisement referred to shows a way to help matters. I do not believe that all the trouble with twisted tangs is due to their actual weakness, but very largely to neglect in seeing that the slots in the collets of drill presses are in proper order. I have often asked a foreman or superintendent if he ever inspected the slots in the drill-press spindles, and have seldom been answered in the affirmative. I feel sure that if the taper is a proper fit, and the tang also, the latter will rarely twist off with regular work.

Your editorial on the "efficiency engineer" is just to the point. That expression is a slur on the engineering profession, as it intimates that an "inefficient" engineer is also a calling. In my experience, the aim of all conscientious engineers has been the production of high quality at low cost—to get all that was possible out of the plant under the existing conditions. What is that if not efficiency?

I cannot quite join you in your time-saving idea mentioned in the editorial entitled "Saving Time in Machine Work." It is safe to say that we will find, if we analyze the operation of drilling a single piece, that not over 10 per cent of the total time is actually used in cutting metal. Drawing down the lever and throwing in the feed are not operations which require much time, and it is my belief that great time saving could be accomplished in securing the work rather than in handling the machine. Often the appliances for securing work on drill presses consist of a number of bolts and straps in a box which have to be dumped on a bench or on the floor in order to find the desired bolts. Usually a trip to the store-room for missing nuts is required, unless they can be conveniently appropriated from the very carefully guarded collection of the planer hand, who is generally the autocrat of the machine shop. To cut a long story short, I believe that time saving in drill press work is in the direction of appliances to quickly get the drill to do its actual work, and not in automatic adjuncts to the press. However, the reciprocating motion in the drill press shown on page 471, is certainly a very convenient addition. We have all worked the hand-feed lever at times to cut a keyway on a drill press, and wished for just such an attachment as this.

It is perhaps not difficult to understand why a drill press has so few appliances, and why those that are provided are so poor. Most likely it is because this machine is especially everybody's tool, unless the shop is a very large one. All hands do work on it, feeling no responsibility towards it, and only considering it their duty to get the job done, and the sooner they can get away from the machine the better. Unless a man is caught "red-handed," the drill marks on the table are done at night when it is positively known that the drills play "tag," and just get into the drill-press sockets all by themselves, which, of course, accounts for the disreputable appearance of the table. This curious night behavior of tools needs scientific investigation. I have known milling cutters or special tools to be taken in perfect condition to a tool-room at night, only to be found in bad shape the next morning, and even when a broken piece is found with the work done by it, it is merely a strange coincidence.

It seems strange to me that the multiple drill makers do not provide some kind of adjustable drill guides, as it would greatly enhance the value of these tools.

In answer to D. A. H.'s question as to rejected parts, my advice would be to destroy them at once, so that they cannot be used, or else you may be tempted to make use of them to the detriment of your reputation. Just be a Pharaoh and harden your heart, but do it at once, and make it part of your system.

"Amateur," judging from his letter on page 464, certainly is in trouble. The explanation of using a lathe for fine drilling "beats" anything that I have so far seen in print, and it is somewhat on a par with the advice given in a celebrated hand-book of engineering, where the following appears: "Boring.—For brass the speed is *one-half* that for cast iron." This shows the truth of the statement of the school-boy who said, "If it wasn't for books, we wouldn't know nothin'." W. D. F.

* * *

The development of electric rock drills of the percussion type has imposed the most severe requirements on steel used for the drills and hammers, but the economy of electric installations has made the development worth while. It is claimed that the electric drill using from one-half to two horsepower will equal the work of a compressed air drill using twelve to eighteen horsepower at the compressor. The changing of line wires is simple as compared with the shifting of pipes. Countervailing disadvantages are the dangers of short circuits and sparks and the lack of the fresh air that is a feature of the exhaust of compressed air drills of some importance.

University of Iowa

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW DESIGNS AND IMPROVEMENTS
IN AMERICAN METAL-WORKING MACHINERY AND TOOLS

WIGGLESWORTH BORING, DRILLING AND TAPPING MACHINE

The Western Machine Tool Works, of Holland, Mich., has recently placed on the market a boring machine especially adapted for heavy boring, drilling and tapping operations. This machine is capable of driving 4-inch drills in steel and will operate an 8-inch pipe tap in cast iron. The general features of the machine may be seen by referring to Figs. 1 and 2,

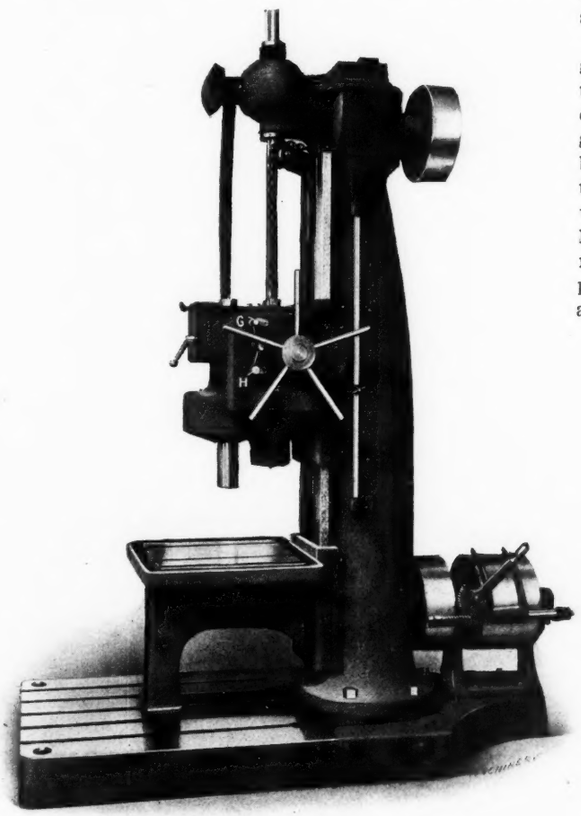


Fig. 1. Boring, Drilling and Tapping Machine, built by Western Machine Tool Works

of the accompanying illustrations, which show views of each side. When the machine is in operation, the spindle remains in a fixed longitudinal position with relation to the driving mechanism and spindle-head and the latter is automatically fed downward on the face of the column. The machine has nine changes of positive geared feed, ranging from 0.006 inch to 0.042 inch per revolution of the spindle, and, in addition, three positive geared "leads" for tapping eight, eleven and one-half and fourteen threads per inch. These tapping leads are independent of the feed changes and any desired lead may be obtained by means of extra change gears.

As will be noted, a belted connection is made between the countershaft on the base and the quick-change speed gear-box on the top of the column. By means of the speed change gears, eight different spindle speeds are obtained and this number is doubled by back-gears located in the head, thus giving a total of sixteen speeds, ranging from 25 to 400 revolutions per minute. From the gear-box the power is transmitted to the spindle head through horizontal and vertical shafts connected by bevel gears. There are three of these bevel gears and a friction clutch, which form the reverse mechanism for tapping. The lever *D*, Fig. 2, for operating this friction clutch, is located conveniently on the left-hand side of the head.

The spindle is driven by a large gear in the head. This gear is located in a fixed position near the lower end of the spindle and close to the work. This arrangement reduces the torsional strain on the spindle and tends to eliminate the chattering incident to heavy cuts. The automatic down-feed to the head is derived from a spiral gear located near the upper end of the spindle, the power being transmitted through feed change gears (as explained later) and a pinion which meshes with a rack in the face of the column. With this arrangement, the feed operates in conjunction with the spindle movements.

Figs. 3 and 4 show the construction of the quick-change gear-box which is located on top of the column and governs the spindle speeds. Shaft *A* is keyed to the belt pulley and, consequently, rotates at a constant speed. A cone of four gears, *B*, is splined to shaft *A* and can be shifted longitudinally by fork *C* which slides on a fixed stud in the gear casing. To the rear of this fork there is a straight rack engaging gear *D*, which is keyed to the vertical shaft *E* so that rotating the latter shifts the cone of gears *B*. The variable speed is transmitted to shaft *F* on which is mounted a rocker arm *G* having pivots *H* and *H'* supporting two sets of intermediate gears *J* and *J'*. Gears *J'* are directly geared to pinion shaft *F*, whereas

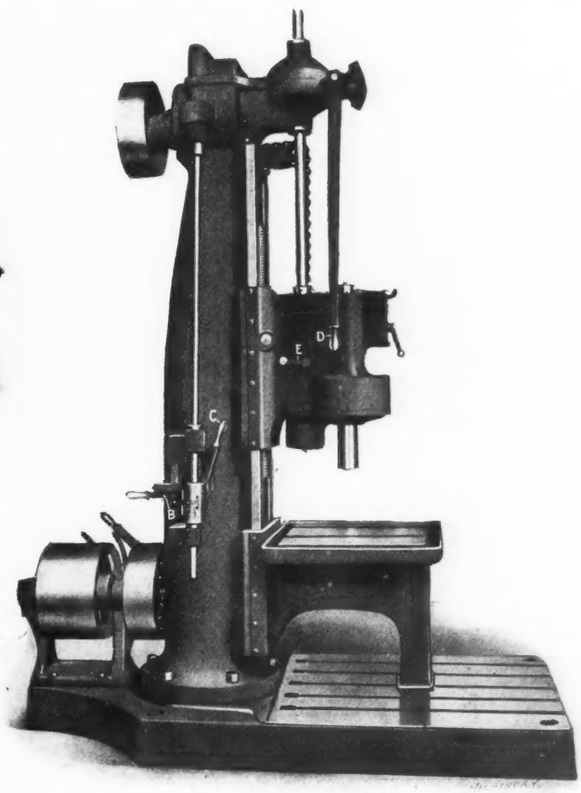


Fig. 2. Another View of Wigglesworth Boring Machine

J is connected by compound gearing as shown. On the upper end of rod *E* there is a circular rack which engages corresponding teeth in the sector face of rocker arm *G*. This rod may be raised or lowered and it can also be rotated to the right or left. Any vertical movement rocks arm *G* and permits either *J* or *J'* to mesh with one of the gears on shaft *A*, whereas rotating *E* to the right or left shifts cone *B* on shaft *A* to bring any one of the four gears into engagement with *J* or *J'*. By varying the gear combinations in this way, eight spindle speeds are obtained. The vertical and rotary movements of rod *E* are effected by the two levers *B* and *C*, Fig. 2,

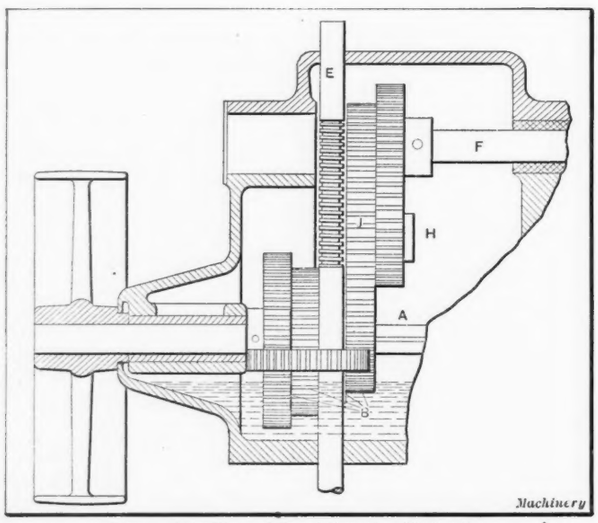


Fig. 3. Side View of Speed-changing Mechanism

which operate through the medium of a cylindrical part attached to the rod.

The method of driving the spindle either directly or through back-gears, is clearly shown in Fig. 5. The vertical shaft *P*, which receives its motion at the top of the column, carries gears *B* and *X*, and the spindle carries the mating gears *Y* and *Z*. Gear *B* is splined to shaft *P* and when in the position shown, the spindle is driven through back-gears. To obtain a direct gear drive, gear *B* is dropped down inside gear *X* (which is bored out to receive it) by means of lever *E*, Fig. 2. Gear *X* has a large hub on its lower side and on the inside of this hub a two-jaw clutch is cut. This clutch is engaged by the corresponding clutch on gear *B* when the latter is lowered, and then the drive is direct from *X* to *Z*.

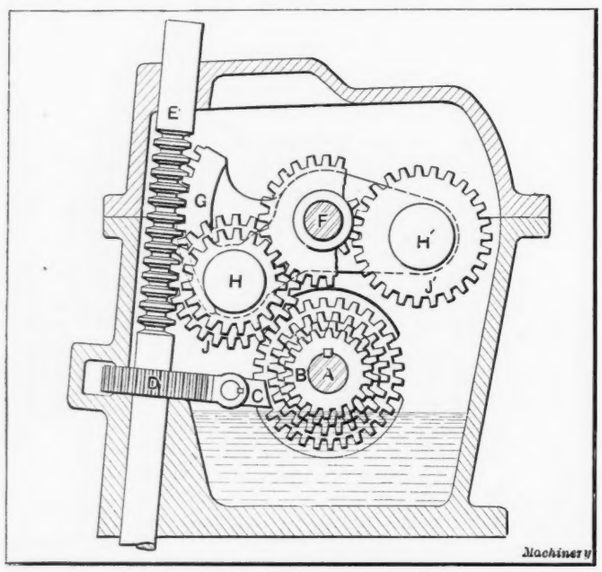


Fig. 4. End View of Speed-change Gears

The details of the positive geared feed mechanism are shown in Figs. 6, 7 and 8. The power is derived from the spindle by a spiral gear *Q* which drives shaft *C*. The latter transmits movement to shaft *D* through three spur gears located in the small box seen on the front of the head in Figs. 1 and 2. (Incidentally, the different tapping leads are obtained by replacing gear *T*, Fig. 9, with another size). Shaft *D* carries five gears as shown in Fig. 7, all of which run loose on it excepting gear *X*, which is attached by a key. The two gears to the left on *D* are locked together and any one of the three middle gears may be keyed to the shaft by a diving key mechanism. This diving key is operated by lever *G*, Figs. 1 and 8, located on the right-hand side of the head. Above the three middle gears referred to, there is a cone of mating gears *E* (Figs. 6 and 7) which run loose on their shaft and are all joined together. Shaft *F* also carries three gears

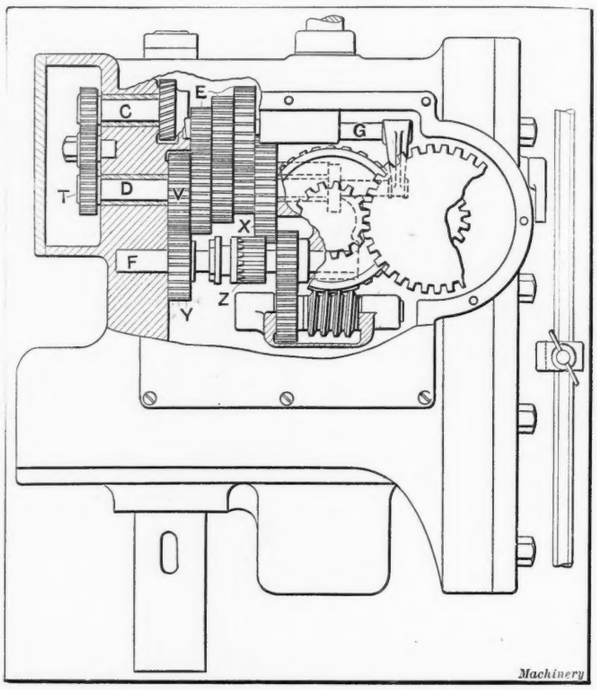
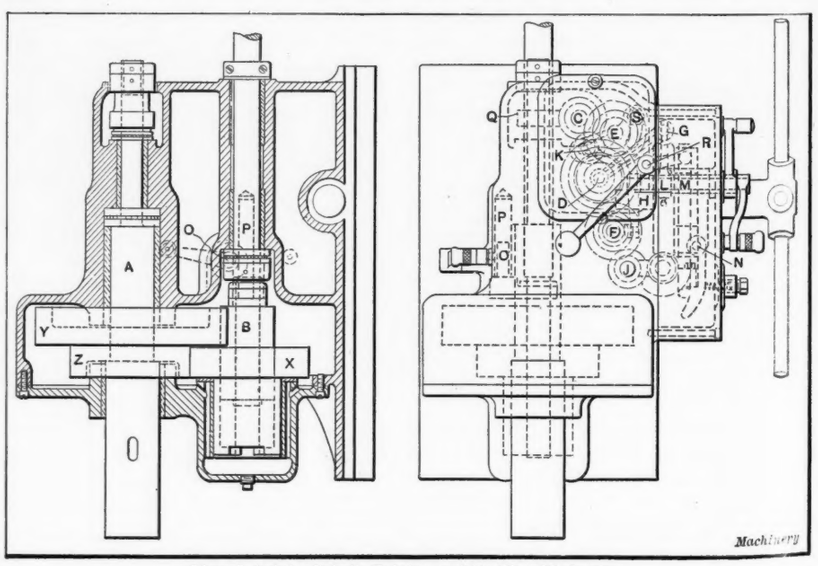


Fig. 7. The Positive Geared Feed Mechanism

and the one to the extreme right is attached by a key. Gear *Y* runs loose on the shaft and gear *Z* has a positive clutch formed on the hub and is splined to the shaft. When tapping is being done, the drive is from shafts *D* to *F* through gears *X* and *Z* and when the regular spindle feeds are desired, gear *Z* is shifted to the left (by lever *H*, Fig. 8) until its clutch engages a corresponding clutch on gear *Y*, thus locking the latter to shaft *F*. The feed movement is then transmitted from *D* to *F* either directly through gears *V* and *Y* or indirectly through the cone of gears *E*, depending on the position of the dive key. Three feed changes are obtained by shifting the dive key and, by the use of two change-gears at *T*, six



Figs. 5 and 6. Spindle Driving and Feeding Mechanism

additional variations are secured. From shaft *F* power is transmitted to the feeding worm by a spur gear on shaft *J*, Fig. 6. The worm is hung in a bracket pivoted around shaft *J* and it can be raised into mesh with the worm-wheel by lever *F* (see Fig. 9) on the front of the head. When the worm is in mesh, it is secured by a finger *f* (Fig. 8). The feed is transmitted from the worm-wheel through the spur gearing shown in Fig. 7, to a rack secured to the face of the column which gives the vertical movement. The power feed can be automatically tripped at any point by means of an

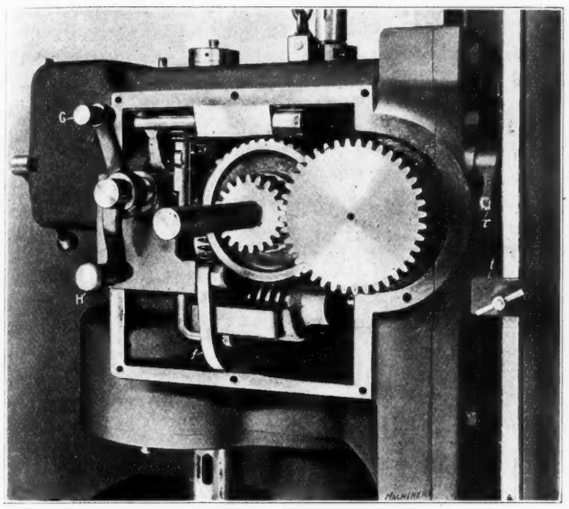


Fig. 8. Feed Box with Cover Removed

adjustable stop *t*, Fig. 8, which engages with lever *r*, thus releasing trigger *f* and allowing the worm-wheel to drop out of mesh. The spindle-head has an automatic down-feed on the column of 40 inches, and the distance from the column face to the center of the spindle is 14½ inches.

The design of this machine is compact and extremely rigid throughout. In case it should be desired to bore open-end cylinders or similar work, provision has been made for steadying the lower end of the bar, it simply being necessary to drill and bore a hole through the table into a hub on the under side and insert the necessary bushing. The lower end

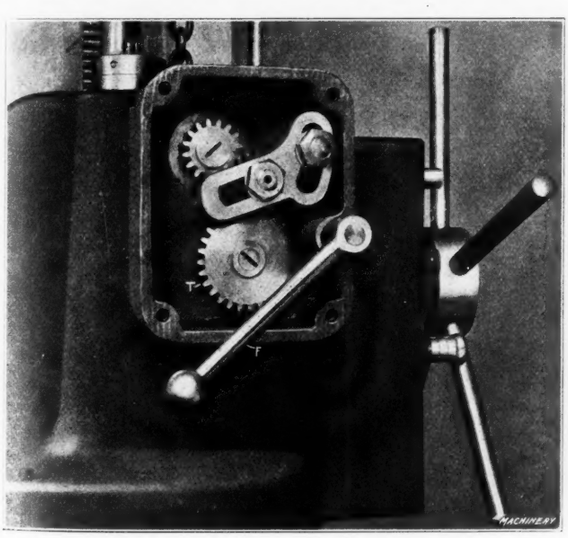


Fig. 9. Front Gear Box with Cover Removed

of the boring-bar can then be passed through this bushing which forms a rigid support.

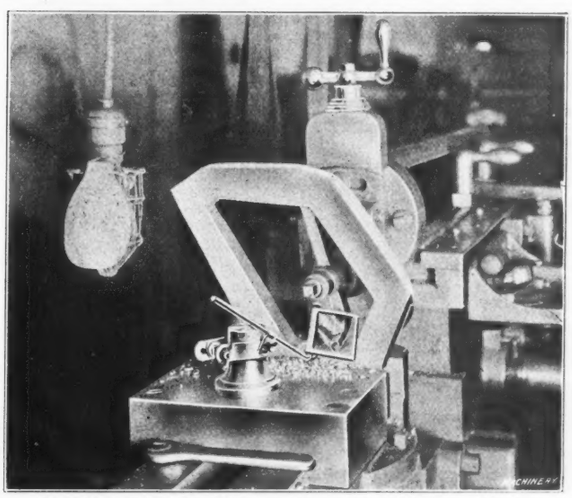
The lubrication of this machine has received careful attention. All gears in the head and quick-change box run in a bath of oil, and the head alone will hold seven gallons of lubricant. The bearings are made self-oiling by means of wicks fitted into slots milled in the bearings, the ends of the wicks dipping into oil reservoirs. The loose pulley on the countershaft also has a wick, the end of which dips into a reservoir cored out of the hub. These reservoirs hold enough oil to last for several months.

In case a motor drive is desired, the motor can be mounted on the back of the column in place of the countershaft. The weight of the machine is about 8500 pounds. It may be seen in operation at the demonstration shops of Hill, Clarke & Co., Inc., in Boston and Chicago, and in the branch offices at New York, Philadelphia, Cleveland, Milwaukee and Rochester.

UNIVERSAL CHIP GUARD

In the department of New Machinery and Tools for April, 1911, we illustrated a lathe chip guard manufactured by the Universal Stamping Co., 47 Poultney St., Buffalo, N. Y. This guard is now equipped with a stationary base block as shown in the accompanying illustration to adapt it for use on the shaper. The bottom of this block is covered with rubber, which prevents any slipping from the jar incident to the shaper's motion. Either a plain glass or a magnifying glass may be inserted in the holder. The magnifying glass not only protects the eyes of the operator but magnifies the lay-out lines on the work, which is often desirable, especially in connection with toolmaking.

The utility of a guard of this kind is shown by a report on the cause of shop accidents. From a total of 670 accidents in connection with lathe work, 127 were caused by flying chips, or by the flying out of articles being turned. Of course, most of these accidents were not very serious and



Method of using Chip Guard in Connection with Shaper Work

did not result in permanent injury, but the figures show that the protection afforded by a chip guard is very much needed for certain classes of work.

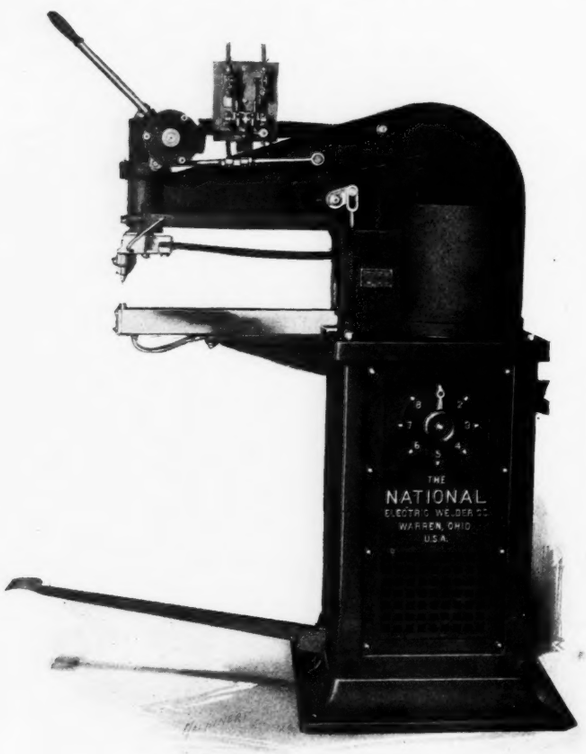
NATIONAL ELECTRIC SPOT WELDER

The use of the electric welding process, especially in connection with sheet metal work, is rapidly superseding the older method of riveting, in the manufacture of a great many parts. Many articles formerly made of wood are now constructed of sheet steel, which has resulted in still further increasing the use of the electric welding process. The spot welder not only gives an increased production, but a neater finish, which is an important feature in connection with many classes of work.

The electric spot welder shown herewith is a product of the National Electric Welder Co., Warren, O. This is a 24-inch size, which means that it will weld to the center of a 48-inch sheet. When this machine is equipped with points or dies not more than ⅜ inch in diameter where they bear on the work, it is said to make 1000 spot welds in 16 gage steel or iron for ten cents, with current costing four cents per kilowatt hour, or three cents per horsepower hour. An alternating current is used, and the 12- and 24-inch standard spot welders have an improved shell-type transformer of 15 kilowatt capacity, designed to reduce the line voltage to 4½

volts, which is the highest voltage required. The machine also has a regulating coil which gives eight different voltages at the welding points. These variations are indicated by a dial at the side of the machine, which is placed in the proper position by the handwheel shown. This feature is necessary, as the voltage required to spot weld varies with the thickness of the material.

This machine is equipped with an automatic switch so designed that it is absolutely impossible to turn on the operating current until the welding points are brought firmly into contact with the metal to be welded. The act of releasing the pressure on the points also immediately opens the switch, which prevents burning the work or destroying the



Electric Spot Welder, built by National Electric Welder Co.

copper points. The welding points are cooled by a continuous stream of water flowing through them, which increases their durability.

The machine can be operated either by hand or independently and without making any changes or adjustments. The use of the foot-lever permits the operator to hold and adjust the work between the welding points with both hands. The use of the foot-treadle, however, gives exactly the same results as when the hand lever is employed. When the machine is operated by the hand lever, the foot lever does not move and it can be removed readily if desirable. The extended hand lever can also be easily taken out as it is fitted into a socket in the clutch plate.

The switch is a new design of the double-pole, double-break type, having four points of contact. This switch opens both sides of the primary circuit in two places, which avoids excessive flashing with currents of high amperage and voltage. This switch is placed on top of the machine and it has the advantage of being stationary, which avoids any trouble from the crystallizing and breaking of the flexible leads. The contacts of the switch are so designed that they can be removed readily. A complete set of contacts costs only a few cents and will ordinarily last from six months to one year.

Two pieces of ⅜-inch boiler plate can readily be welded together with this machine. Sheet steel 1/16-inch thick can be welded at the rate of thirty spots or welds per minute, and ⅛-inch steel stock can be welded at the rate of twenty spots per minute. This machine is designed to be "fool-proof," which not only minimizes the cost of maintenance, but increases the output.

BARNES DRILLING MACHINE

The Barnes Drill Co., 814 Chestnut St., Rockford, Ill., is now manufacturing a 26-inch all-geared drill of the sliding-head type. This machine, with the exception of the sliding head, is designed along the same general lines as the all-geared type formerly built by this company. Fig. 1 illustrates a standard machine, and Fig. 2 is a view showing the opposite side of a machine equipped with a motor drive.

This design is said to have the power of an ordinary 36-inch, cone belt driven type. There are eight geared speeds and a similar number of geared feeds, all of which may be controlled from the front of the machine. The feed for any position of the controlling lever is shown by plain figures, and the feeds range from 0.005 inch to 0.086 inch per revolution of the spindle. The spindle is 1 15/16 inch in diameter in the sleeve and it is double splined. The crown and pinion gears are of extra large diameter and have teeth of four pitch, thus giving a strong drive. The head and spindle are counterbalanced by a weight inside the column which is suspended on a roller-bearing sheave wheel. The head is securely locked to the column face at any point within its travel, by two quick-

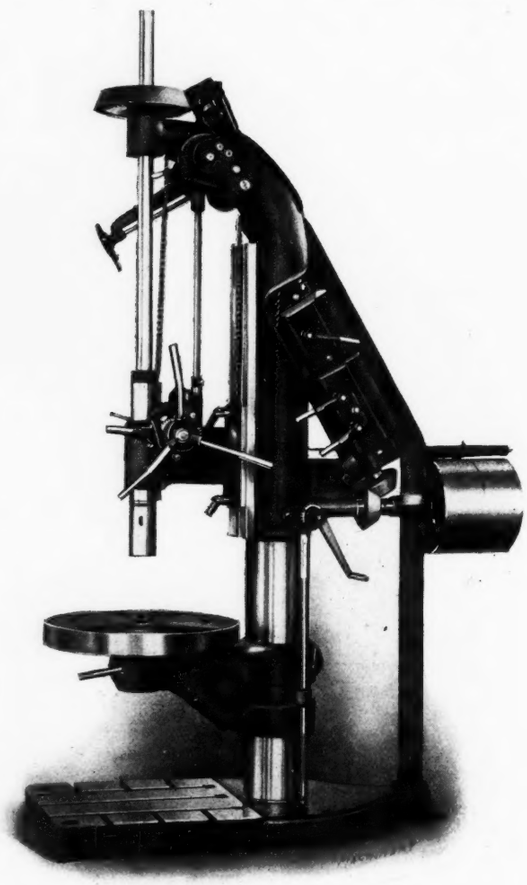


Fig. 1. Barnes 26-inch All-geared Drilling Machine, with Sliding Head

acting clamp screws, and it is raised and lowered by a crank pinion and rack which may be seen in Fig. 2.

This machine is guaranteed to drive a 2-inch high-speed twist drill with a feed of 0.041 inch per revolution of the spindle and at the rate of 6½ inches per minute, in cast iron without using the back-gears. A drill of this size has been driven at the rate of 8¼ inches per minute during tests. A 1-inch high-speed twist drill can be driven through cast iron at the rate of 13½ inches per minute, provided the drill itself will stand this pace.

Suitable feeds are available for boring-bar work, and the machine will bore holes 8 inches in diameter or even larger.

State University of Iowa MAY 1912

The machine illustrated in Fig. 2 is equipped with a special boring-bar which is used for boring and reaming the exhauster bodies of vacuum cleaners. The holes are 6 inches in diameter and 6½ inches deep, and the work is said to be done very accurately. The sliding head is necessary in connection with this work, in order to remove the tools. The adjustment of the head can be easily effected by the rack and pinion movement, previously referred to. It will be seen that the boring heads, two of which are shown on the base of the machine, are equipped with pilot bars. This same machine is also used for boring the bearings, one of which is shown at the foot of the column.

Some of the general dimensions of this machine are as follows: Distance from column to center of table, 13¼ inches; diameter of column, 7½ inches; diameter of table, 23 inches; vertical travel of table, 20 inches; vertical travel of spindle

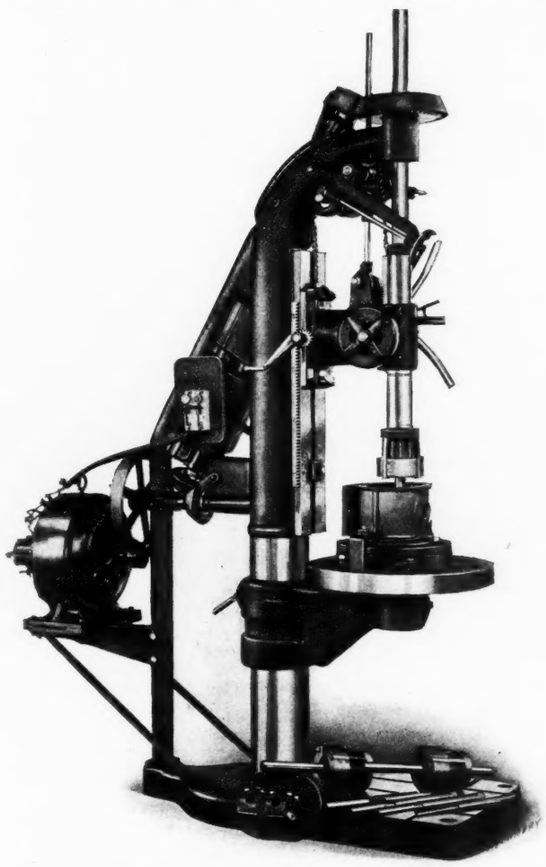


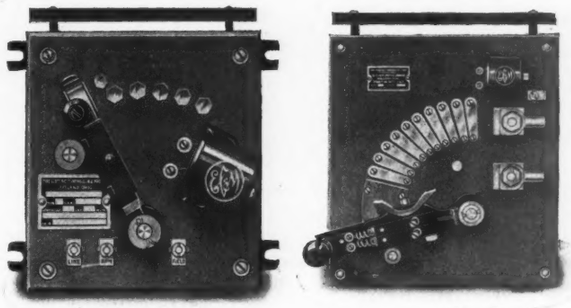
Fig. 2. Barnes Drill equipped with Motor Drive

for one position of the head, 14 inches; adjustment of the sliding head, 23 inches; maximum distance from spindle to base, 54 inches; minimum distance, 18½ inches; maximum distance from spindle to table, 40 inches; ratio of back-gearing, 4 to 1; diameter of the crown gear, 10 7/16 inches; diameter of bevel pinion, 5 inches; net weight of machine, 1750 pounds.

MOTOR-STARTING RHEOSTATS

The Electric Controller & Mfg. Co., Cleveland, O., has brought out a new line of starting rheostats for series, shunt or compound wound, direct-current motors. The contacts on all sizes of these rheostats, can be removed from the front without disassembling or interfering in any way with the wiring or resistance. The retaining magnet is iron-clad, thus being protected from mechanical injury. The resistance wire, the capacity of which is liberally proportioned, is wound on asbestos-covered, metallic tubes through which a draft of air flows. This draft of air conveys the heat away from the resistance, but does not at any time touch the hot resistance wire; the result is an unusual freedom from oxidization of the resistance wire.

These rheostats are regularly furnished in sizes varying from ¼ horsepower to 35 horsepower for 110 volts, and from ¼ horsepower to 50 horsepower for 220 and 550 volts. Starters similar to the style shown in Fig. 1, are supplied for



Figs. 1 and 2. Rheostats made by Electric Controller & Mfg. Co.

motors up to and including 7½ horsepower with 110 volts, 15 horsepower with 220 volts and 20 horsepower with 550 volts. For larger sizes, the type shown in Fig. 2 is used.

BROWN PYROMETER WITH ILLUMINATED DIAL

The Brown Instrument Co., of Philadelphia, Pa., has added to its line of electrical pyrometers, a new illuminated-dial indicator having an exceptionally long scale. Frequently an

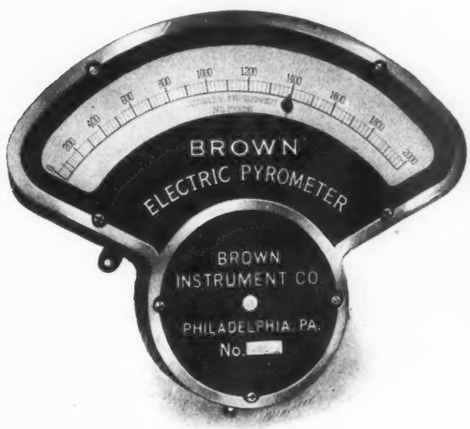


Fig. 1. Brown Pyrometer

instrument is desired which can be read easily by the operator of a furnace or kiln, at some distance, and this pyrometer with an illuminated dial is particularly desirable for just such conditions. This instrument has a scale 12 inches long and

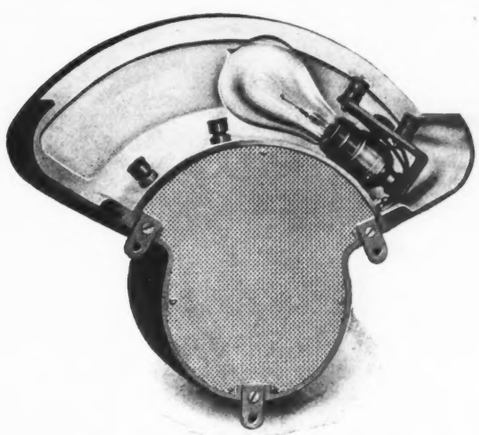


Fig. 2. Rear View of Pyrometer showing Method of Illuminating Dial

it can be furnished without the illuminated dial if desired. Where the illumination is sufficient, the instrument does not require an illuminated dial, as the long scale affords very open graduations and accurate readings. In many plants, however,

where there are dark rooms for hardening and heat treating steel, and where work is carried on day and night, the illuminated instrument is preferable. The scale is drawn on opaque glass, and a sixteen candle-power lamp is placed behind the scale, which makes the graduations and the pointer stand out clearly at a distance. Better results are often secured with this instrument because more accurate readings of the temperature can be obtained.

SAFETY LATHE DOG

Every machinist who has operated a lathe realizes the danger connected with the use of the ordinary lathe dog with its unguarded set-screw which tends to catch in the clothing, especially when filing. A safety lathe dog has been brought out by Elmer J. Michaud, S. Windham, Conn., which is so

Safety Dog and Ordinary Type

shaped that the set-screw is guarded. This new dog and also the ordinary type is illustrated herewith. The "tail" of the safety dog is curved around in front of the set-screw on the leading side—as determined by the direction of rotation—thus affording protection. This feature does not affect the convenience of loosening or tightening the set-screw.

UNIVERSAL EMERY WHEEL GUARD

The emery wheel guard illustrated in Fig. 1 is designed to be applied to practically any make of shop tool-grinder. It will cover emery wheels up to 8 inches in diameter and 1½ inch thick. This guard covers the outside of the wheel and also the end of the spindle and retaining nut. The inner side of the wheel is left open to permit using the full width

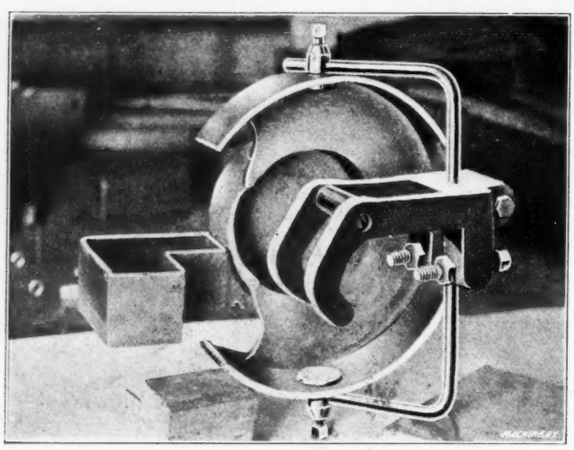


Fig. 1. Emery Wheel Guard made by Universal Stamping Co.

in case this is necessary. The application of this guard to a tool-grinder of the bench type is illustrated in Fig. 2. The guard proper is supported by a steel rod which, in turn, is held by a clamp attached to the spindle bearing box. This clamp, the form of which is clearly shown in Fig. 1, is made in two pieces which are held together by two cap-screws. It is clamped over the bearing boxes by two set-screws, which are locked with jam-nuts. By loosening the rear cap-screw on the clamp and the two binding posts seen above and below the guard, the supporting rod can be raised or lowered or swung to the right or left, thereby allowing the guard to be adjusted as the wheel wears. The water pan is located just below the grinding rest and is attached to the guard proper

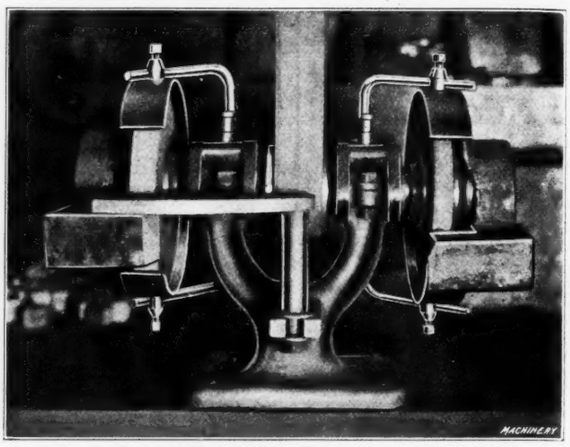


Fig. 2. Tool-grinder equipped with Universal Wheel Guards

by a screw. This pan is not only useful for cooling purposes, but aids greatly in settling the dust. It can be attached or removed quickly for cleaning or filling. When this guard is properly adjusted there is no chance of emery or grindings flying into the eyes of the workman. It is manufactured by the Universal Stamping Co., 47 Poultney St., Buffalo, N. Y.

SENECA FALLS 12-INCH QUICK-CHANGE LATHE

The Seneca Falls Mfg. Co., 330 Water St., Seneca Falls, N. Y., has just placed on the market a 12-inch quick-change lathe of the same design as the 14-inch size described and illustrated in the department of New Machinery and Tools for December, 1910. The quick-change feed mechanism of this lathe provides forty-eight changes for the lead-screw, which is also used as a feed-rod. All standard threads from 1½ to 92 per inch, including 11½, can be cut, and feeds varying from 0.0023 to 0.142 inch per revolution of the spindle are available.

The index plate shows clearly how to obtain any thread or feed. There is a micrometer stop for the cross-slide by means of which minute adjustments can easily be made. The stop is adjusted by a worm-gear operated by a screw having a knurled knob. The graduations on the micrometer barrel are about ⅛ inch apart and represent 0.00025 inch. The stop mechanism is thrown in or out of engagement by a knob inside the handwheel. The reverse mechanism for the cross and longitudinal feeds and lead-screw consists of a set of spur gears and clutch in the headstock. The reverse mechanism is operated through levers connected by a rod with a hand lever arm on the apron. An automatic stop for the carriage operates in either direction by means of adjustable stops on the reverse rod. The headstock is a deep web pattern and has a forged crucible steel spindle revolving in large bearings provided with oil rings. A draw-in chuck with collets up to ¾ inch can be furnished. A new binding device secures the plain and compound rest to the cross-slide. An automatic safety device prevents engaging opposing feeds, and the feed gearing is disengaged when cutting threads so that the longitudinal handwheel does not revolve.

POLISHING STAND OR JACK

The general appearance and interior arrangement of a new polishing stand or "jack" built by F. E. Wells & Son Co., Greenfield, Mass., is shown in the half-tone engraving, Fig. 1, and the line illustration, Fig. 2. This machine was first built for the company's own use and proved so satisfactory that it has been placed on the market. By referring to Fig. 1, it will be seen that the machine is intended to be driven from beneath the floor. With this form of drive any chance of accidents from the driving belt is eliminated and

all of the mechanism is self-contained. The enclosed construction also furnishes an ideal protection for the bearings from dust.

The interior mechanism is shown by the sectional and side views Fig. 2. The driving belt which connects with a driving pulley beneath the floor, runs over pulley *C* on the main shaft *D* of the machine. This shaft runs in bronze boxes the bearings of which are lubricated by means of ring oilers *L*. The driving belt normally runs slack and then the spindle or polishing shaft *D* is at rest. The machine is started by simply depressing the hand lever *H* at the side of the column. This lever controls the movement of an idler pulley *F* which is

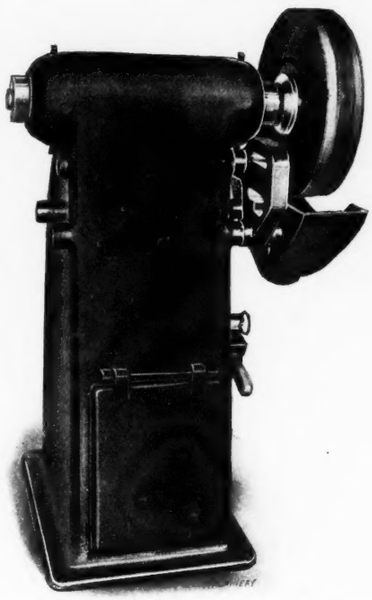


Fig. 1. Polishing Jack built by F. E. Wells & Son Co.

mounted on shaft *E*, contained in a yoke that fulcrums about shaft *G*, so that when lever *H* is depressed, the idler pulley is forced against the driving belt thus tightening it. Lever *H* has an adjustable weight *I*, and when the idler pulley is thrown into contact with the belt it is retained in that position by the engagement of pin *J* with a projection *K* on the frame of the machine. As soon as the idler is swung away from the belt, the spindle *D* is quickly stopped by a brake *M*, which is automatically applied by the backward movement of the idler yoke. This machine can be equipped with a special

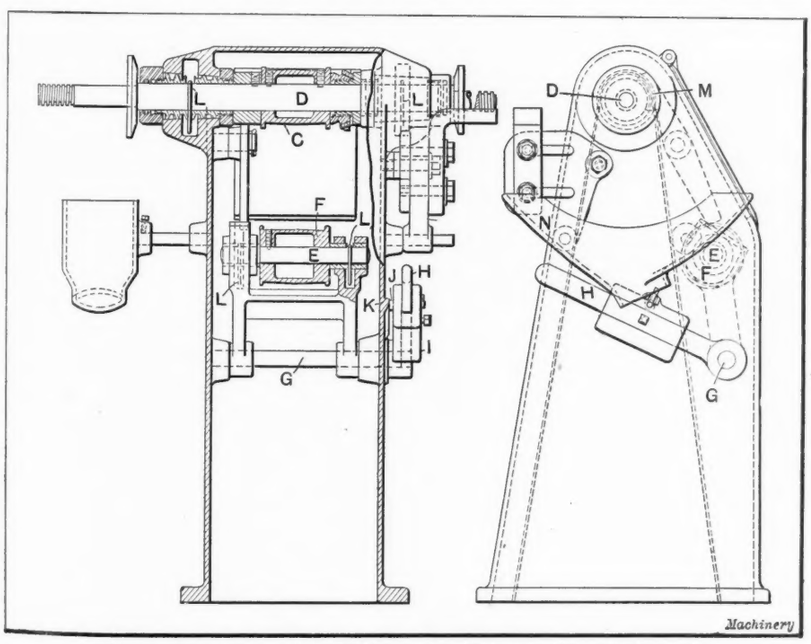


Fig. 2. Views showing Idler Belt-tensioning Device of Wells Polishing Jack

shaft for carrying two wheels in case this is desirable. A swinging arm with a table for disk grinding can also be furnished.

FARWELL UNIVERSAL GEAR HOBBING MACHINE

The Adams Co., 874 Market St., Dubuque, Iowa, has added to its line of gear hobbing machines, a No. 4 size adapted to the cutting of spur or spiral gears, worm-wheels and worms,

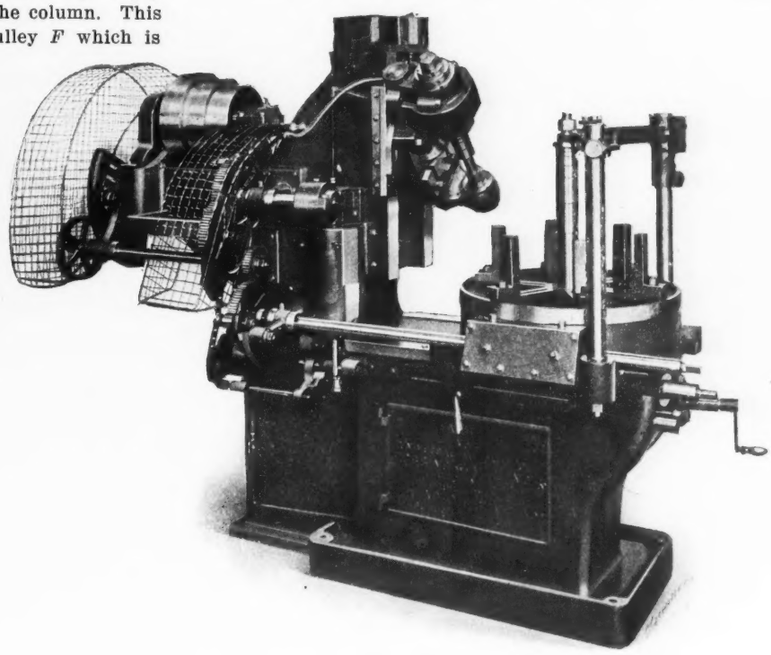


Fig. 1. Farwell Universal Gear-hobbing Machine

up to 24 inches in diameter and with 3 diametral pitch in cast iron and 3½ pitch in steel. This machine, a general view of which is shown in Fig. 1, has such a wide range of feeds and table speeds as to make it universal.

Change gears can be furnished for cutting a single-thread worm or a screw of fine pitch and, in addition, worm, spiral or spur gears, having a wide range as to the pitch and number of teeth, can be hobbed. The vertical feeds of the cutter head range from 0.002 to 0.500 inch per revolution of the table. The table may be geared to make one revolution to two revolutions of the cutter, or it may be geared to make one revolution to a thousand or more revolutions of the cutter. This wide range of feeds and table speeds is, of course, unnecessary for ordinary spur, spiral and worm-gear cutting, but no additional complication was incorporated in the design to obtain this range. The drive for the table and feeds is such that the compounding of a comparatively small number of moderate size gears enables this range to be obtained.

This machine is especially designed for gear- and worm-hobbing, but the slow table travel relative to the cutter speed, which is available, enables the machine to be used also as a continuous or circular milling machine. A special spindle and bracket, such as is shown in Fig. 3, may be secured for this purpose. The cutter-head has been made as rigid as possible by using a wide saddle and swivel of heavy construction. The cutter spindle is large and has a hole through which the arbor proper passes. The arbor is driven by a long key, and adjusting nuts on the arbor at each

end of the spindle provide a longitudinal adjustment of the hob. The spindle is driven by a steel spur gear and pinion, and both the spindle and pinion shaft run in adjustable bronze bearings located on each side of the gears, thus equalizing the strain.

There is but one pair of bevel gears in the spindle drive. A reducing gear of large diameter is interposed between the cone-pulley shaft and a universal-joint shaft which transmits power to the spindle. This is the same drive which has been satisfactorily used on the No. 3 machine. The universal joints are of special design and are provided with large wearing surfaces of steel bearing on bronze. Wear can be compensated for readily, and there are felt oil retaining pads to facilitate lubrication. The cutter-head has an automatic stop and a rapid power return movement.

The table saddle has a power inward feed ranging from one-quarter thousandth to three-eighths inch for each revolution of

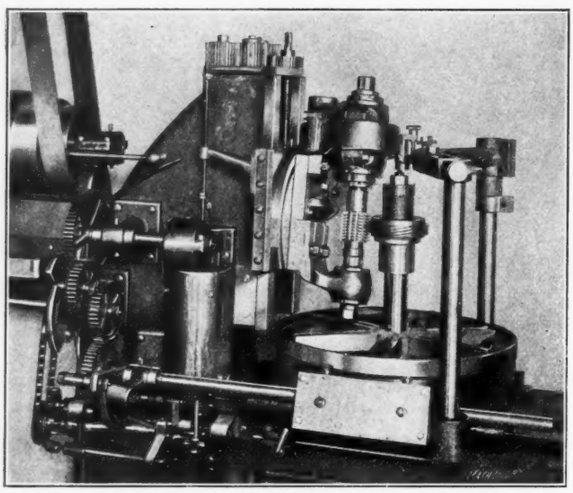


Fig. 2. Farwell Machine cutting Spiral Gear having Tooth Angle of over 80 Degrees

the table. An automatic depth stop is provided for worm-wheel hobbing. The table may be geared to cut anything from a single-threaded worm to a gear having a thousand or more teeth, including all prime numbers. A regular set of change gears (120 in number) will give all the feeds mentioned and will enable gears having any number of teeth up to 200, to be

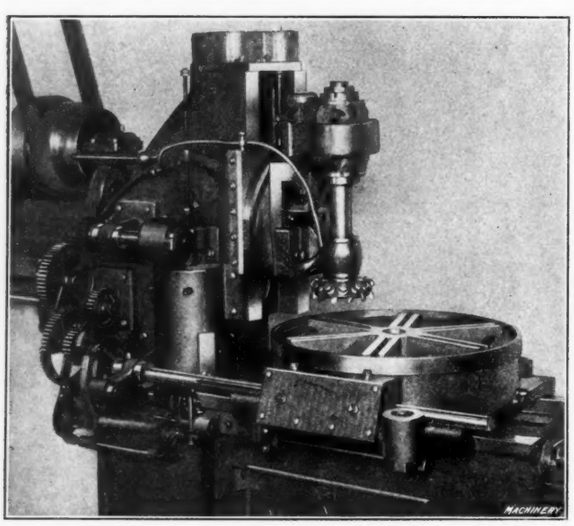


Fig. 3. Gear-hobbing Machine arranged for Continuous or Circular Milling

cut, and many composite numbers above the figure mentioned. Special gears can be furnished to cut all other numbers including prime numbers.

The countershaft furnished is provided with three clutch pulleys, giving a hobbing speed in both directions and a slow speed for driving milling cutters. The lubricating pump is arranged to run in the right direction when the direction of the spindle is reversed. The table is driven by a steel worm engaging a bronze ring worm-wheel. This worm-wheel is 20 inches in diameter which is within four inches of the machine's maximum capacity. Provision is made for easily taking up any wear, either in the mesh or end motion of the worm. The table is of heavy rib or spoke-and-rim construction, and the top between the ribs, instead of being level, is

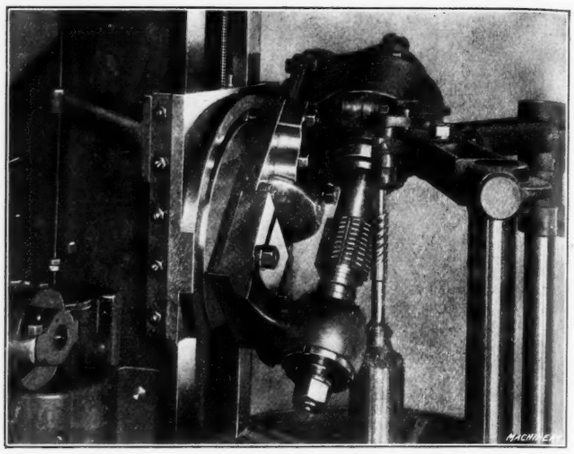


Fig. 4. Hobbing Small Five-threaded Worm on Gear-hobbing Machine

depressed to a cone shape. This conducts all chips and lubricant into a pan in the base of the machine. The lubricant drains out of the pan into a tank below. The pan may be removed easily through the door shown, when necessary. The weight of the machine, complete, is about 3900 pounds.

NIAGARA POWER DOUBLE SEAMER

The machine shown in Fig. 1 of the accompanying illustrations, is made by the Niagara Machine & Tool Works, Buffalo, N. Y., and is especially designed for double-seaming the heads of drums and other sheet-metal packages. The

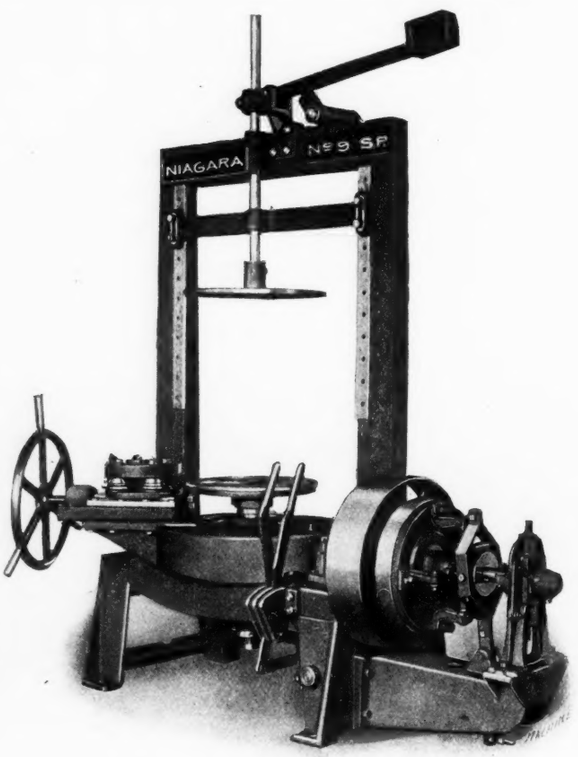


Fig. 1. Niagara Power-driven Double Seaming Machine

heads must be previously stamped to the proper shape by means of a press and dies. The work to be double-seamed is clamped between the top disk and the lower double-seaming chuck, which is shaped to suit the work. The chuck is driven by means of bevel gears, and the spindle carrying the chuck

has an adjustable end thrust bearing. The carriage with the double seaming rolls mounted in a turret head, is actuated by means of a screw and the handwheel shown. Either two or three rolls are used according to the type of the seam and thickness of the material. The motion is controlled by a friction clutch actuated by one of the hand levers seen at the right side of the lower chuck. The other lever is used to bring down the upper clamping plate, which is counterbalanced.

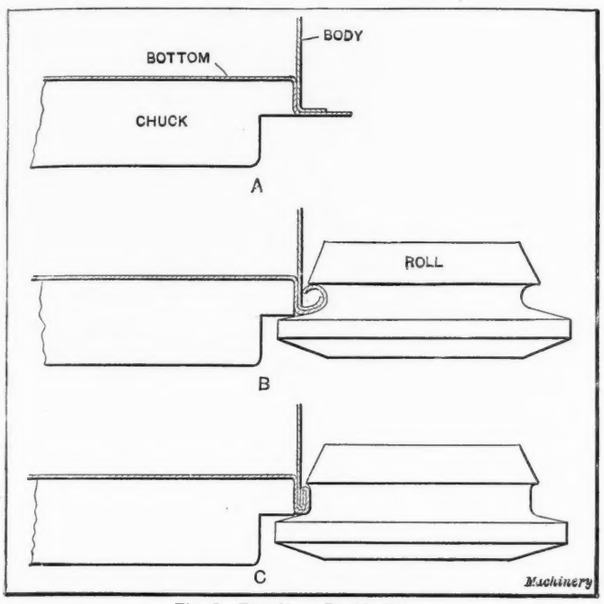


Fig. 2. Forming a Double Seam

The successive steps connected with forming a double seam are illustrated in Fig. 2. The first view at *A* shows the body and bottom of the work assembled and ready for seaming. The first seaming roll is then brought up against the flanges on the work which are turned over as indicated at *B*. The turret is then indexed, thus bringing the finishing roll in position. This roll is then moved in against the work, thus flattening and locking the seam together as indicated at *C*. This seamer has a capacity for work varying from 10 to 32 inches in diameter and not exceeding 45 inches in height.

TURNER HOT BLAST TUBULAR TORCH

The Turner Brass Works, Sycamore, Ill., has designed a hot-blast gasoline torch, which is about five feet long, two inches in diameter and is made of heavy gage brass tubing. This new torch produces a very hot blast flame which is easily controlled by the gasoline valve. There is a powerful burner at one end, and the gasoline valve and pressure pump is located at the other end, as shown in the accompanying illustration. The long tube forming the body contains the gasoline that is delivered to the burner. This tube holds about three quarts. A controlling valve inside the tube regulates the flow of fuel in such a manner that the torch can be used in any position, the flame being pointed up or down, as required. Air pressure for the blast is pumped into the gasoline chamber, the same as in any other torch, by means of a pump at the end of the tube. The flame is about two inches in diameter at the burner and approximately twelve inches long.

This torch is intended for foundry use in connection with drying and baking sand molds, and it can also be used for preheating purposes, burning paint (especially on a large scale) thawing out frozen pipes, melting ice, and for heating the ground in advance of general construction work. Other uses for a torch of this form will readily suggest themselves. The weight of the torch is about seven pounds.

UNIVERSAL VISE AND SURFACE TABLE

The vise illustrated in Fig. 1 has a universal adjustment which makes it possible to hold odd-shaped parts, as well as ordinary shapes in the best position for the workman. The swiveling base gives an angular adjustment and the vise can be raised or lowered to the most convenient height. The vise can also be turned about the axis of its supporting column. These various adjustments enable the workman to secure the best light on lines or prick-punch marks indicating finished surfaces, and they also prevent stooping or working in an awkward attitude as is often necessary with the ordinary fixed vise. The vise is rigidly held in any position by a single clamping lever, and when a vertical adjustment is made, the vise is held automatically until the lever is tightened by a locking collar on the stem. These vises are made in four styles and four sizes.

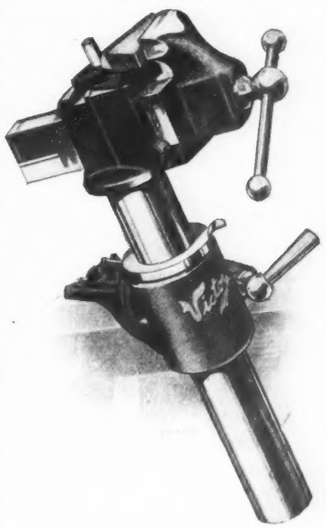


Fig. 1. Vise having Universal Adjustment

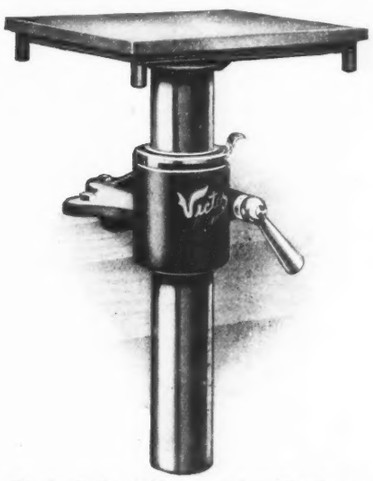


Fig. 2. Surface-table mounted on Vise Base

An accessory to this vise is illustrated in Fig. 2. This is a surface-table or plate which can be mounted in the base as shown. This plate can also be detached from the stem and used on the bench, the same as an ordinary surface-plate. The sizes of these plates are made to suit individual requirements. These vises and surface tables are the product of the Victor Vise Co., 15-19 W. Washington St., Springfield, O.

ROCKFORD HAND MILLING MACHINE

The No. 3 hand milling machine built by the Rockford Milling Machine Co., Rockford, Ill., is now equipped with a power longitudinal feed whenever such a feed is desirable. The arrangement of the feed mechanism is very simple. The power is derived from the rear end of the main spindle, which carries a three-step cone-pulley. This pulley connects by belt with a lower pulley mounted on the end of a universally-jointed shaft which transmits motion, through gearing, to the work-table. By reversing the cone pulleys, six changes of feed can be obtained. This machine has the regular combination screw and lever feed. These two feeds do not interfere, and the change from one to the other can be quickly made. The advantage of this double feed arrangement is obvious. This machine can be used for either horizontal or vertical milling, and, by means of special attachments, it is adapted to a wide range of work. There is a longitudinal power feed of

Turner Hot-blast, Tubular Gasoline Torch

11 inches, a transverse feed of 4 inches and a vertical movement of 6¼ inches. The working surface of the table measures 18 by 4¼ inches.

BRADFORD GEARED-HEAD MOTOR-DRIVEN LATHE

The Bradford Tool Co., Cincinnati, O., has brought out a geared-head, motor-driven lathe, which is a departure from conventional designs, as will be seen by referring to Fig. 1. This lathe is designed to eliminate top-heaviness and vibration, and, at the same time, secure a more compact machine by locating the motor as indicated in Fig. 2. The lathe has a mechanical reverse movement and mechanical speed changes which are easily and quickly made. If a constant speed motor is used, eight spindle speeds varying from 12 to 398 revolutions per minute, are available, and an indefinite number of speeds can be obtained by using a 1½ to 1 variable speed motor, having a simple starting and regulating rheostat.

An effort has been made to arrange the speed controlling levers so conveniently that the operator will always use an efficient speed. A selective type, automobile design of speed-box is incorporated in the drive and provides four of the speed changes. The revolutions per minute of the lathe spindle are plainly marked on a plate which shows the four positions of the speed-box lever and the right and left positions of the lever seen on the head. All of the changes are obtained by these two levers, and the speed-box lever is locked automatically when the lathe is running, thereby preventing breakage. The lower gear-box shaft is continued to the left of the gear-box and is in driving connection by means of a pair of gears as well as by a pair of Morse silent chain gears, with a short countershaft driven direct by a pinion on the end of the motor shaft. Either the gear or chain drive is engaged by friction clutch members controlled by the long shifter handle seen above the lathe. This feature enables the lathe to be run forward or backward and also provides an effective brake for stopping quickly when working up to shoulders. A shot-bolt in positive operating connection with the main clutch operating lever, prevents shifting the gears under load. The peripheral speed of the gears is very low. All parts are of easy access, and particular attention has been given to the matter of lubrication.

The head has for its first driver a short shaft carrying a Morse chain-wheel and a gear-wheel, both of which are in driving connection, respectively, with a chain-wheel on the right-hand upper gear-box shaft and a friction-clutch-operated gear on the main spindle. The latter gear is in driving connection with a gear on the back-gear shaft. This shaft also carries another gear which is, in turn, in driving connection back again to the lathe spindle by means of a second positive clutch-operated gear on the spindle. The lever seen on the head is in operative connection with the friction and positive clutches which respectively engage the high- and low-speed gears with the spindle. All supplementary speeds

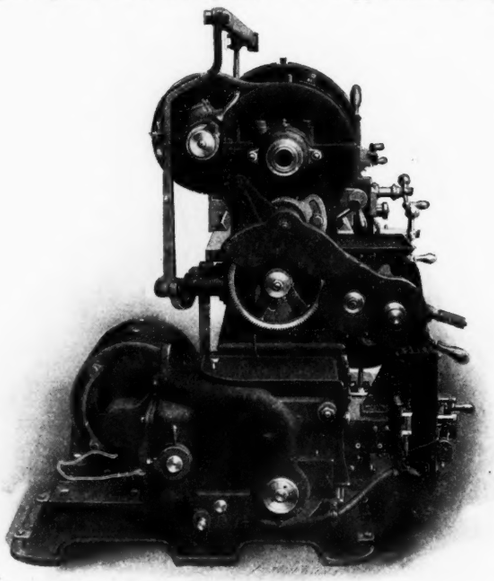


Fig. 2. End View of Bradford Lathe showing Location of Motor

are obtained by the simple regulating rheostat, which is located just below the quick-change gear screw-cutting mechanism.

The quick-change gear device is of the well-known Bradford type and enables the cutting of all standard and pipe threads, including 11½ per inch. The gears are of forged steel, and ordinary change gears can be used direct between the spindle and lead-screw for cutting any odd thread. An automatic stop for the longitudinal feeds is provided regularly. The apron is equipped with a thread indicator and chasing dial, the worm-wheel of which can be disengaged from the lead-screw by a cam and knurled knob, thus avoiding unnecessary wear. All exposed gears are carefully guarded as the illustrations show, thus protecting both the operator and machine.

The spindle is made from high carbon crucible steel and it is mounted in adjustable, taper, bronze bearings. The bed

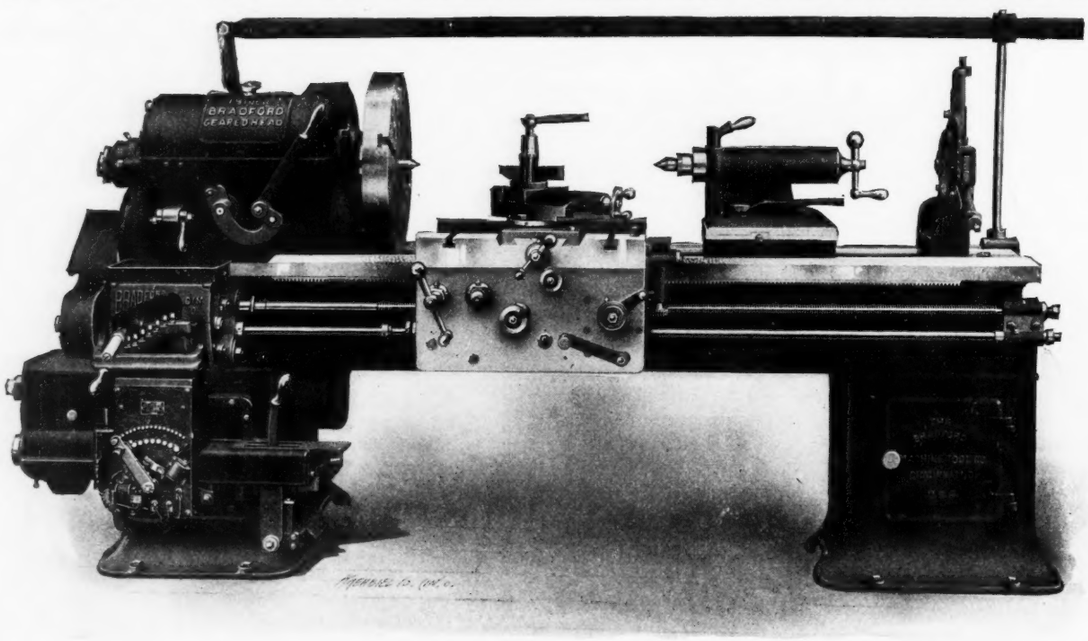


Fig. 1. Bradford Geared-head Motor-driven Lathe

is of extra weight and depth and is webbed in two-foot sections. The carriage has a full bearing on the vees its entire length and is gibbed front and back. The apron is of the double-plate pattern and has a non-interfering device to prevent the feed-rod and lead-screw from being engaged simultaneously. The pinions and studs are of high-grade steel, hardened and ground. The feeds cover a wide range and they are all positive geared. This lathe can also be arranged for a single-pulley drive instead of a motor drive. If a two-speed countershaft is used in conjunction with the selective speed-box and geared head, sixteen forward speeds may be obtained. The drive can be direct from the lineshaft if the latter is suitably located. The motor-driven and single-pulley lathes are made in 18-inch heavy pattern, 22- and 26-inch sizes.

HENDEY RELIEVING ATTACHMENT

The Hendey Machine Co., Torrington, Conn., has brought out an improved form of relieving attachment which can be used to relieve hobs or taps having spiral flutes. This new attachment can also be employed for relieving any of the work for which the design formerly built is adapted. The advantage of the spiral flute is that it gives a cutting edge that is square with the body of the tooth, which is conducive to better and faster cutting. This attachment is shown applied to a lathe in Fig. 1.

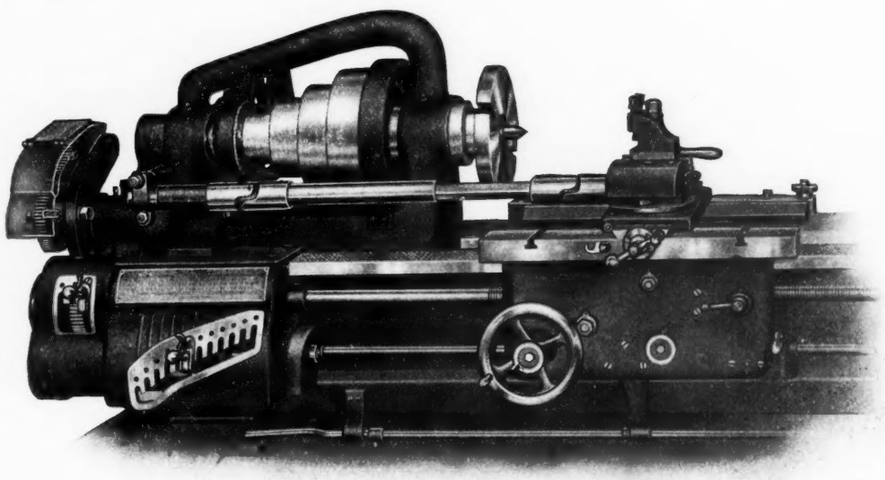


Fig. 1. Hendey Relieving Attachment applied to Lathe

The actuating mechanism is mounted on the main gear-box, the tool pan or cover of which is removed. The tool-slide interchanges with the compound or other rest on top of the cross-slide, and it can be swiveled to different angular positions for side and end relief work, as will be explained later. The mounting of the complete attachment requires but a few minutes. The amount of relief can be varied in a simple and easy manner, by means of a toothed coupling at the ends of the oscillating shaft and cam-lever, which permits the relative position of the eccentric on the tool-slide and the cam-lever to be changed, thereby lengthening or shortening the reciprocating travel of the tool. This adjustment gives the tool-slide a movement varying from zero to 5/32 inch on the 14-, 16- and 18-inch lathes, and the movement is increased to 3/16 inch on the 20-inch lathe, and to 1/4 inch on the 24-inch size.

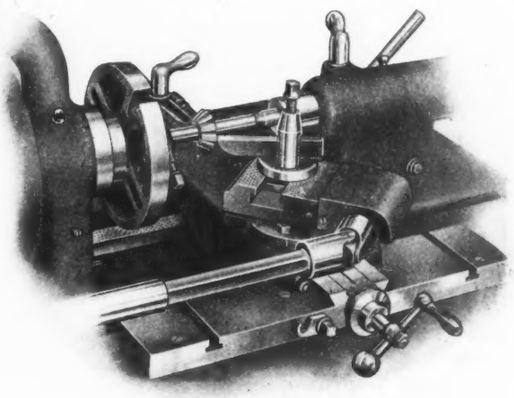


Fig. 3. Relieving Sides of Angular Cutter

If a hob or tap having spiral flutes is to be relieved with this attachment, the pitch of the spiral and the gears necessary to drive the attachment, are first determined. After the attachment is geared to suit the spiral and number of flutes, the lead-screw is engaged and the backing-off operation is performed the same as for straight flutes. The lead-screw should not be disengaged but the carriage is reversed by power, the lever at the right of the apron being used for that purpose. When determining the pitch of the spiral, it should be remembered that quite a variation in length can be made without any serious drawback. Fig. 2 shows the attachment relieving a spirally fluted hob.

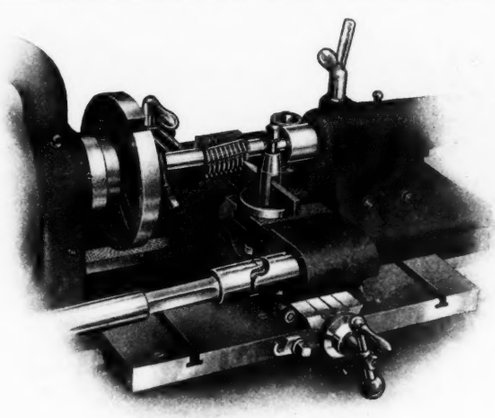


Fig. 2 Relieving Spirally-fluted Hob

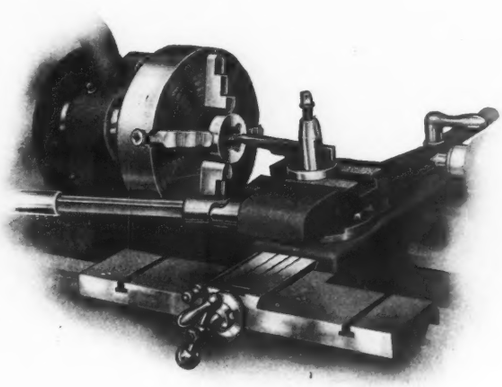


Fig. 4. Attachment arranged for Inside Relieving

Fig. 3 shows the method of relieving the side of an angular cutter. This application is made possible by means of the swiveling tool-slide which enables the tool to be placed in the

proper position. By the use of an additional universal joint and bearing to permit the tool-slide to be swung to a 90-degree angle, counterbores can be relieved as indicated in Fig. 5.

When the attachment is used for relieving inside work such as hollow mills and threading dies, the eccentric which controls the travel of the tool-slide is set so that the relieving movement is away from the axis of the cutter instead of toward it. This change is made by the toothed coupling connecting the cam lever and oscillating shaft, the latter being turned beyond the zero mark in a clockwise direction as far

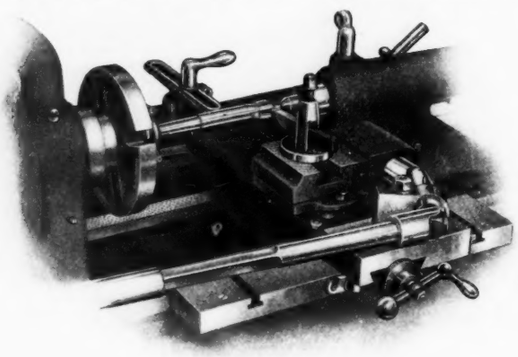


Fig. 5. Relieving a Counterbore

as is necessary to get the desired amount of travel. It is also necessary, for internal work, to change the position of the opposing spring in the tool-slide, so that it will press against the end of the slide and prevent the tool from "jumping" into the work. Fig. 4 shows an example of internal work.

When relieving a right-hand tap, the ordinary practice is to first set the tool as for cutting a thread. The tool is then accurately set with reference to the thread space by rolling

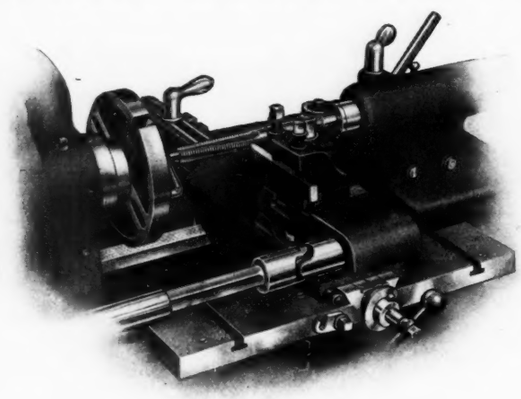


Fig. 6. Relieving Left-hand Tap having Spiral Flutes

the work in the dog or by disengaging the gears in the gearbox. The motion of the tool-slide is then adjusted so that the forward movement of the tool will meet the front of the tooth and the return movement begin promptly after leaving the end.

Left-hand taps can be relieved by two different methods. By the first, the cut is started at the cutting edge and ends at the "heel," and by the second, the start is made at the heel and discontinues at the cutting edge, the tool being drawn out from the work during the cut. When the first method is employed, the tap is placed with the point towards the headstock spindle and the shank end is supported by the tail-center as indicated in Fig. 5. An extension or blank end long enough to take the driving dog, is provided at the point of the tap. With the second method, the tap is held between the centers the same as a right-hand tap, but the travel of the tool-slide is set as for inside relief. As will be recalled, the necessary adjustment is made by the toothed coupling, and the opposing spring, in this case, is left in the same position as for right-hand work.

When work is being relieved, it should be revolved much more slowly than when turning, to give the tool-slide time to operate properly. A maximum of 180 teeth per minute is recommended, and if wide forming tools are used, the speed may be reduced to as low as 8 teeth per minute. It is also essential to use tools having a keen edge, and the tool-slide should work freely but without undue looseness. After a cutter has been formed, it is a good plan to color it either by heating or dipping it in a strong solution of copper sulphate. The operator can then plainly see the work done by the relieving tool and stop at the proper time. Re-milling after the backing-off operation, insures a sharp edge and reduces the amount of grinding necessary after the cutter is hardened.

D. & W. FUSE CO.'S MAGNETIC CHUCKS

As a labor saver, there is probably no form of electrical device which has proved of greater benefit in the machine shop and tool-room than the magnetic chuck. When a large number of pieces are to be machined, the time and labor saved by the use of a magnetic chuck, as compared with the old methods of clamping, or holding one piece at a time in a vise, will often pay for a chuck within a short time. Magnetic chucks of the flat and rotary types now being manufactured by the D. & W. Fuse Co., Providence, R. I., are illustrated in Figs. 1 and 2.

The flat chucks (see Fig. 1) have a horizontal face and are

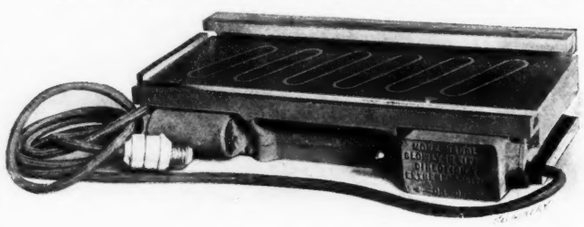


Fig. 1. Magnetic Chuck of Flat Type, built by D. & W. Fuse Co.

equipped with adjustable end and side stops, providing convenient means for locating and steadying the work. This form is particularly useful for holding such work as file blanks, scale blanks, thickness gages, punches, dies, accurate shims, gibs, or practically any part on which it is necessary to grind flat surfaces. Milling operations can also be performed with great facility, if the shape of the work is such that the end stop of the chuck can be raised to take part of the thrust. When used in this way, the smallest flat chuck built by this company will hold a 1- by 2- by 6-inch bar of tool steel, tightly enough to permit milling 0.050 inch from a surface 2 inches wide, and with a feed of 1 inch per minute. This chuck is also useful for holding stock requiring light planing and shaping operations.

The rotary chucks have been used effectively in plants manufacturing ball and roller bearings, for holding ball races dur-

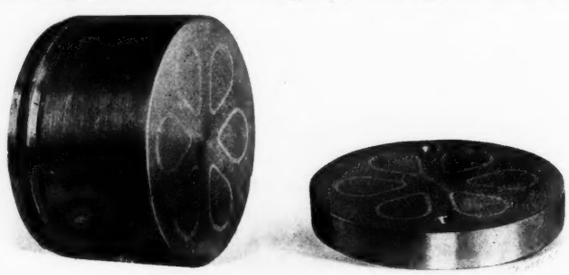


Fig. 2. Rotary Magnetic Chuck and Auxiliary Plate

ing the grinding operations. Rotary chucks are also used for holding pistons and piston rings which must be accurately ground. The rotary chuck illustrated in Fig. 2 is equipped with an auxiliary plate.

This company also manufactures vertical chucks which have a perpendicular holding face when clamped to a horizontal machine platen. They are especially adapted for grinders having a cup-wheel mounted on a horizontal spindle. The chuck proper

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is similar to the flat type. The magnet coils of these chucks are wound with "Deltabeston" wire, having a special heat-proof insulation of pure asbestos. This insulation can safely withstand temperatures as high as 400 degrees F. In addition, the coils are wound by a special process which still further protects them from heat and moisture. This construction prevents burning out of the magnet coils when subjected to variations of voltage, moisture or prolonged service. The coils are rigid units which are interchangeable, and the arrangement of the chuck is such that they can be replaced readily. Auxiliary plates, which are made to fit these chucks, are used as jigs or fixtures for holding special pieces of irregular shape. By means of these plates, one chuck can be made to cover a wide range of operations, as any number of plates can be used.

Both the flat and vertical chucks have their ends machined true so that several of them can be lined up end-to-end for holding long work, or for machining many small parts at one operation. This feature permits the units to be used separately on different machines, or to be assembled into one long chuck controlled by a single switch. With the exception of the smaller sizes, the chucks are designed for use on direct-current circuits of 105 to 125 volts. If it is desirable or necessary to energize them on circuits of higher voltages, such as 210 to 250 volts, or even 550 volts, a convenient form of auxiliary resistance is supplied, which can be inserted at any suitable point in the circuit. The small chucks are equipped with standard external resistance units for use on 105- to 125-volt direct-current circuits.

The chucks are both oilproof and waterproof and are equipped with demagnetizing switches for readily releasing the work. When possible, a special switch is used, which is attached directly to the chuck. This switch, by a simple movement of the hand, automatically and positively demagnetizes the chuck. Where it is not practicable to mount this device on the side of the chuck, an independent control base is provided on which is mounted a knife switch with the demagnetizing unit. When the switches are mounted directly on the chucks, they are entirely enclosed in water-tight iron boxes. This affords thorough mechanical protection and serves to keep emery dust from cutting out the moving parts. Magnetic chucks can only be operated on direct-current circuits, and under no conditions can alternating currents be used. Where direct current is not available, direct-current generators are supplied.

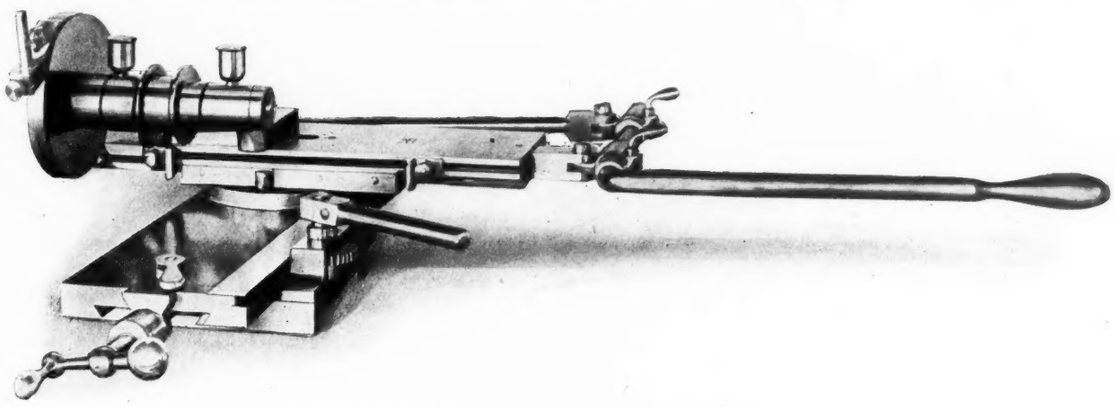


Fig. 1. Remington External Grinding Attachment for Bench Lathes

REMINGTON GRINDING ATTACHMENTS

The external grinding attachment illustrated in Fig. 1 is for bench lathes and is of rigid design with a capacity for grinding wheels 4 inches in diameter and ½ inch face width. The grinding head may be removed and a head for internal grinding substituted if desired. The spindle of the internal grinding attachment is capable of speeds up to 30,000 revolutions per minute. The circular swivel base is graduated in degrees for grinding taper work. The lever movement is novel in that it is adjustable for quick short strokes, as well as for longer strokes. The method of making this adjustment is clearly shown by the illustration. There is a cross-movement of 7 inches from the center. The small lever just above the micrometer feed-screw, serves to release the feed so that the grinding head may be quickly moved to or from the work by means of a rack and pinion actuated by a lever. This feature facilitates the fitting of gages and replacing of the work. The grinding wheel is covered and is provided with an adjustable tube to direct the flow of water for wet grinding.

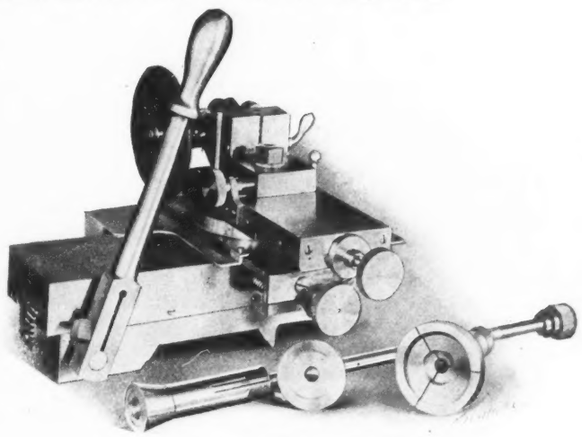


Fig. 2. Another Remington Grinding Attachment

Fig. 2 shows another external grinding attachment for bench lathes, which can be used in connection with the grinding of irregular forms without the necessity of re-setting the work for different angles. This attachment is particularly adapted to grinding hardened steel paper cutters. The illustration shows a paper cutter which has been ground on the plane, concave and bevel sides at one setting. Fine adjustments are provided throughout, both for setting the wheel and to compensate for wear. The circular swivel base is graduated in degrees for obtaining different angular adjustments.

Both of these attachments are recent developments of the Remington Tool & Machine Co., Woburn, Mass., and are designed to be used with the bench lathes manufactured by this company.

CHAMBERSBURG BOARD DROP HAMMERS

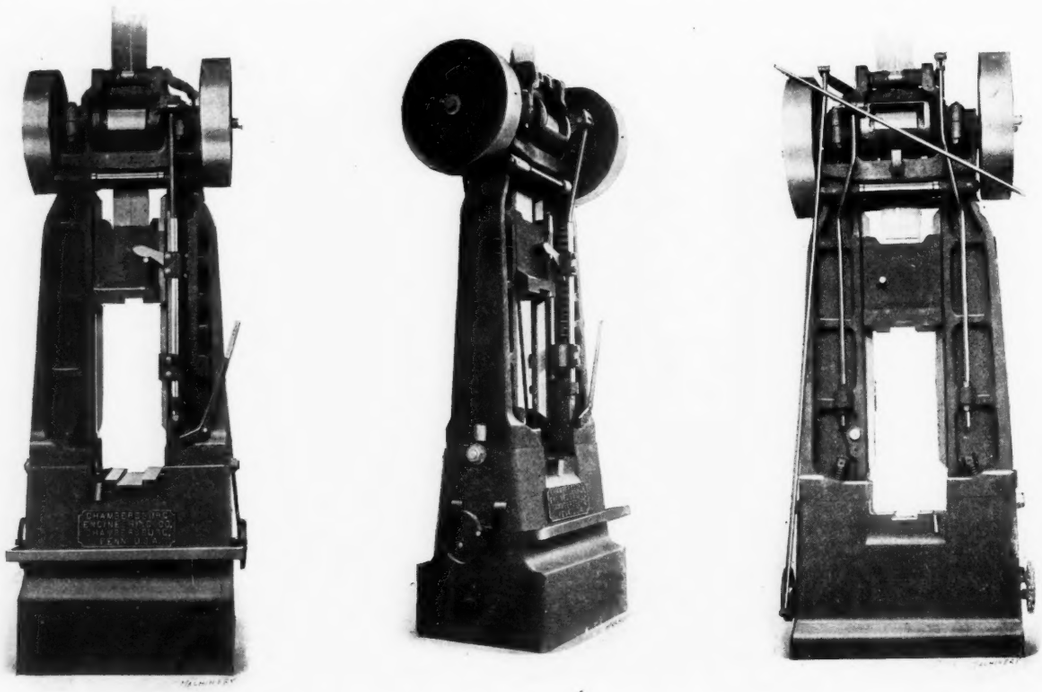
A new line of board drop hammers made in capacities from 400 pounds to 3000 pounds falling weights has recently been brought out by the Chambersburg Engineering Co., Chambersburg, Pa. A hammer of the new design is shown in the accompanying three engravings, illustrating the front, side and back views, respectively. The principal features of the new design are the manner of adjustment for lining up the dies, the manner in which the front rod is lifted up into place, and the knock-off construction. All the features incorporated have been subjected to most rigid and exacting tests in regular service.

The head or lifter is securely held in place on the top of the frames, by four through bolts, which pass through drilled

holes and which have spiral springs to absorb shock. The rolls are furnished either plain or geared, as desired. Together with their driving spindles they are located in hooded eccentrics—the front eccentric being used for operating, while the rear eccentric is for adjustment only. These eccentrics are made from steel castings, in one piece, this method insuring exact alignment. Provisions are made for preventing oil getting onto the rolls where they bear against the boards. The spindle bearings are made of ample size; they are bronze bushed and provided with oil reservoirs.

The board clamps are located at the extreme top on double eccentrics. A permanent alignment of both rolls and board clamps is insured, even if the operator is careless. When the ram is suspended the board is so gripped that it hangs free of both rolls. The board clamps are so designed that they will grip instantly the heaviest rams in any position without sliding, even if the board is badly worn. When the treadle is fully depressed, the board falls freely, no matter how worn it is at the point of pick-up. The trouble of drag through the clamps just before the blow is struck, which is a common difficulty, is thus overcome.

The adjustments necessary to the back roll and board clamp



Figs. 1 to 3. Front, Side and Rear Views of Board Drop Hammer built by Chambersburg Engineering Co.

to take up the wear of the board, are quickly made from the floor by means of adjusting bars led down the back of the machine to within easy reach of the operator, as shown in the rear view of the hammer, Fig. 3. Adjustments can be made for wear of the board up to 7/16 inch. The pulleys may be either Rockwood compressed paper pulleys, or pressed steel pulleys, as desired.

The frames are of reinforced I-beam section to withstand the heavy strains imposed on them in "break-down" work. They are about 2 feet shorter than is the general standard, although the extreme fall of the ram is greater than the average. This feature of design insures greater rigidity. The frames are free from cores, and are of uniform section throughout. They are deeply pocketed in the anvil, having a bearing on their outside edges for the entire length of the tongue, and also bearing on the entire bottom surface, thus insuring satisfactory and permanent alignment of the frames and ram. The tops of the frames are tongued and fitted to the lifter head. The frames are spaced, and held in line with the lifting rolls, by steel tie-bolts with distance pieces. The bearing surface of the V-guides has been made especially large, so as to provide amply for wear.

The frame adjustment to align the top and bottom dies is made by large tension bolts, the construction being such that in case of fracture the bolts can be passed out into the die space and quickly replaced without dismantling the machine. In the usual construction it is necessary to dismantle the entire superstructure to make such repairs. The bolts are supported for their whole length in bored holes. Lock washers are provided to positively hold the adjusting nuts in any position. The frames are designed for the minimum adjustment of 0.0026 inch. The ram or hammer is of 40-point carbon open hearth steel, properly balanced, and made deep enough from front to back to insure the alignment of the dies. The lifting boards are of well seasoned maple, let into the ram and secured by an under-cut plate with teeth on one side so as to enable the use of a straight board, and at the same time prevent the board from pulling out.

The anvil is made of cast iron in one piece, and the anvil cap is made from 40-point carbon open hearth steel. Anvils weighing from fifteen to twenty times the rated falling weight of the ram can be furnished, and can be made of steel, if desired. The anvil is secured to the frames by four bolts, spiral springs being provided to reduce the shock. These bolts are set at a slight angle in order to locate the pocket for the bolt head on the compression side of the anvil, so as to prevent the possibility of breakage due to bolt-head pockets on the tension side.

The front rod lever has a safety stop, which will positively prevent accidents while adjusting dies, etc., as it automatically drops and locks the front rod release when the hammer is not in use, or when the operator is adjusting the dies. This provision prevents many accidents that occur from this source. As indicated in the engravings, the foot treadle does not extend across the back of the anvil, but leaves this space free for forgings.

The stroke is adjusted by means of a rack and segment lever, and the adjustment can be quickly and easily made. The front rod, due to the eccentric construction, is practically straight, and is lifted up into place without the usual shock and jar, as the releasing lever is rolled along in the rack, and gives the front rod a direct and gradual "pick-up." The adjustment for various heights of dies is made by means of a knock-off, clamped to the lower part of the front rod, this adjustment allowing the use of any thickness of dies. The incline for the knock-off is so laid out that no impact is imparted to the front rod. The breakage of the front rod, due to crystallization, which has been a constant source of trouble in this

class of machines, is thus obviated. This design permits the hammer to run at a higher speed than is ordinarily used, thus increasing the output.

RELIANCE SPEED DIAL FOR MACHINE TOOLS

As the output of a machine tool depends to a great extent on the use of the most efficient cutting speed, it is very important to have some accurate method by which the operator can easily adjust the driving mechanism, so as to obtain the prescribed speeds for the cutting tool under different conditions. When the speed changes are effected by means of cone-pulleys or gears, the spindle has a definite number of revolutions per minute and the speed for different gear combinations is usually shown on a plate attached to the machine. It is a comparatively easy matter to embody in a blueprint specified instructions showing the step of the cone-pulley, or the gear combination, which will give the most efficient speed for each operation to be performed. With an individual adjustable-speed motor drive, the number of speed changes is, of course, greatly increased and it is more difficult to indicate the proper combination for a given cutting speed. Consequently, the speed adjustment is usually a matter of guesswork, with the result that the efficiency of a given machine depends largely on the judgment of the operator.

The Reliance Electric & Engineering Co., 1056 Ivanhoe Road, Cleveland, O., has developed a speed dial which enables the operator to obtain the required cutting speed under different conditions. This dial is calibrated for use with the Reliance adjustable-speed motors, and can be applied to shapers, drills, lathes, milling machines, boring mills or any machine tool having speed variations. The Reliance adjustable-speed motor is of the armature shifting type and has an infinite number of gradual speed changes, so that it is always possible to obtain a given cutting speed, provided the operator has some means of accurately adjusting the speed of the motor in accordance with the cutting speed required. The function of this speed dial, one form of which is illustrated in Fig. 1, is to

Fig. 1. Reliance Speed Dial for obtaining Proper Cutting Speed--This Particular Dial is intended for a Back-geared Crank-shaper

enable the proper adjustment of the motor to be made. The dial can be mounted on the machine at any convenient place and it is simply necessary to provide a positive connection with the means employed for shifting the armature of the motor. Fig. 2 shows one of these dials applied to a drilling machine. As the illustration shows, positive connection is made with the motor by a chain and sprockets. The upper sprocket is mounted on a shaft carrying a handwheel which is used in making the adjustments. As the armature of the motor is shifted and a gradual change in speed is obtained, a pointer moves on the speed dial and shows what adjustment must be made to obtain the desired cutting speed. The scales on the dial are, of course, graduated differently for different types of machines, and take into account the different gear ratios between the driving motor and the cutting tool. Therefore it will be seen that this speed dial is not a means of indicating the speed at which the motor is running, but is an automatic calculator which enables the operator to quickly adjust the motor speed so as to obtain any desired speed at the cutting tool and, as previously stated, the dial is arranged to take care of all the variable factors which would affect the problem. All the operator has to do is to set the dial for the

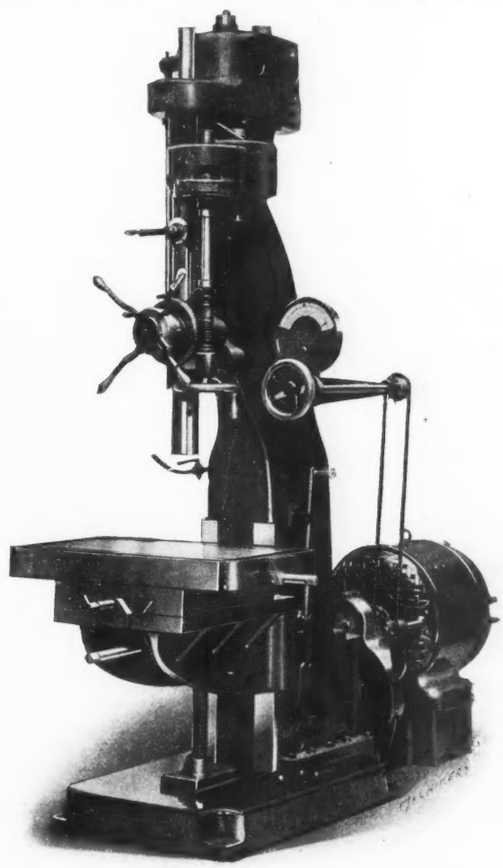


Fig. 2. Foote-Burt Drilling Machine equipped with Speed Dial which is positively connected to Reliance Adjustable Speed Motor

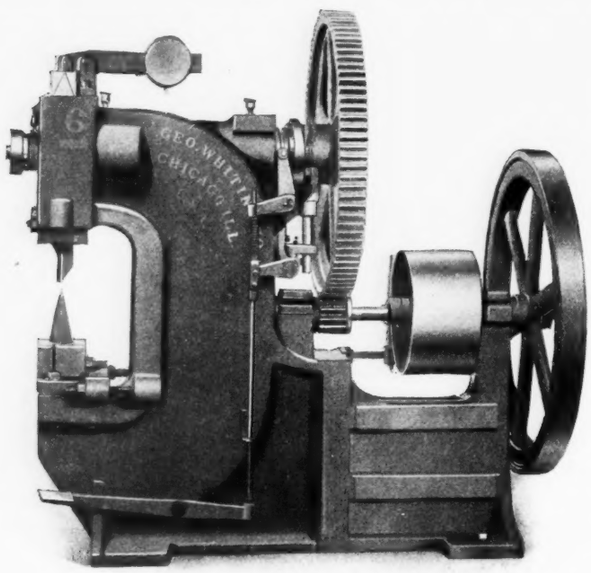
cutting speed required and then shift the armature of the motor, in the usual manner, until a pointer indicates the diameter of the cut to be taken (in the case of lathe work) on the proper scale for the gear combination used.

The particular dial illustrated in Fig. 1 is intended for use on a crank-shaper. This dial has an upper scale which shows the cutting speed in feet per minute, and two lower scales indicating inches of stroke. The upper scale for the stroke is used when the back-gears of the shaper are engaged, and the bottom scale is used when the back-gears are out and the drive is direct. The scale showing the cutting speed in feet per minute, is stationary and the small pointer seen opposite figure 40, is mounted on revolving disks with the two lower scales. When mounted on revolving disks with the two lower scales. When the shaper is to be set for a given cutting speed, the lower scales and the pointer referred to, are turned, by means of the small knurl seen just below the center of the dial, until the pointer is oposite the desired cutting speed. The armature of the motor is then shifted by turning the handwheel seen in Fig. 1, until the pointer over the lower scales (which is geared to the handwheel rod) is opposite the stroke to be used. Of course when making this adjustment, the operator uses the lowest scale if the back-gears are out, and the one above it if the back-gears are in mesh. The illustration shows the dial set for a cutting speed of 40 feet, with a stroke of 20 inches, and the back-gears engaged. It should be remembered that the cutting speed of a crank-shaper depends on the length of

the stroke for a given motor speed, and that is why the scales are graduated for the different lengths of stroke. The convenience and advantage of this dial and its effect on the efficiency of a tool, are obvious. It not only serves as a guide in setting the speed accurately, but is always in plain sight so that the foreman can see what speeds are being used.

WHITING GEARED SPRUE CUTTER

A geared sprue cutter recently designed and built by the George Whiting Co., 1701 Elston Ave., Chicago, Ill., for use in steel foundries, is illustrated herewith. The knives on the particular machine illustrated are intended for cutting off risers, gates and sprues up to the capacity of the machine, but if desired, an extra pair of cutters can be furnished for



Geared Sprue Cutter for Steel Foundries

trimming light fins from steel castings. These cutters are made so that the cutting edges come as close to the casting as practicable. The knives can be set either at right angles to the throat or with the cutting edges parallel to the throat.

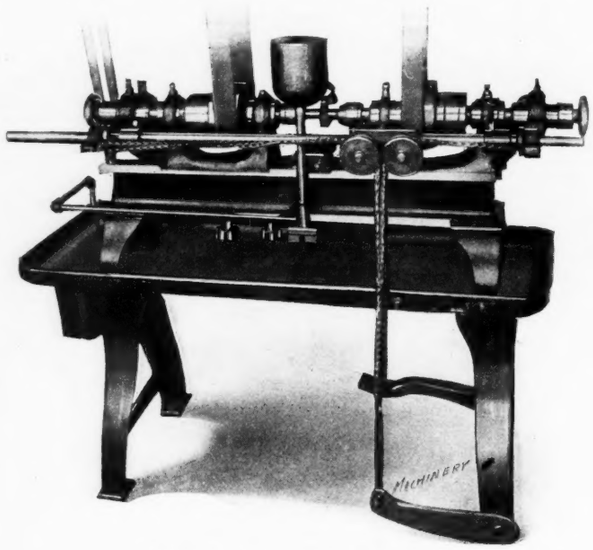
This machine is fitted with an automatic stop and is equipped with tight and loose pulleys. The large flywheel at the rear is crowned for a belt in case a motor drive is desired, and provision is made for attaching a motor directly to the machine. There are means of compensating for the wear of the lower blade, and the knives have been designed so that they can be re-ground economically and, at the same time, have serviceable edges for general work.

The machine is made in different capacities and either with or without the geared drive. The geared type runs about thirty strokes per minute and the quick-acting machine makes about ninety strokes per minute. The lower block which holds the cutter, is provided with an adjustment for aligning the blades to secure accurate cuts. The upper head can also be adjusted vertically for setting the top cutter in the proper position. This machine is designed to enable the operator to work as close to the casting as possible.

DUPLEX DRILLING AND COUNTERBORING MACHINE

A special drilling and counterboring machine built by the F. E. Wells & Son Co., Greenfield, Mass., is shown in the accompanying illustration. This machine operates on both sides of the work simultaneously, by means of opposed horizontal spindles. The particular machine illustrated is used for drilling and counterboring wrench parts. One spindle carries a combination drill and counterbore and the opposite spindle a counterbore only, so that a hole is drilled through the work and counterbored on each side.

The construction of the machine is very simple as the illustration indicates. The two spindles are moved toward each other by means of a foot-treadle. This treadle is connected

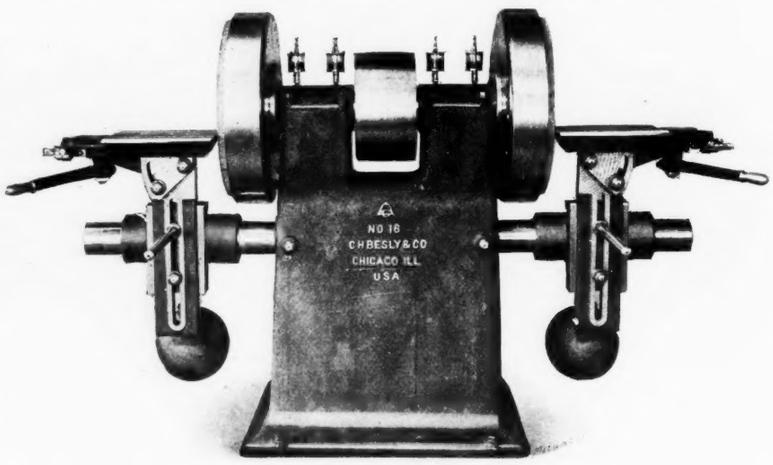


Drilling and Counterboring Machine

with the spindles by chains which pass over sheaves and are attached to arms connecting with the spindles. A guide rod at the rear of the machine takes up the torsional strain on the spindles when the drilling and counterboring tools are at work. Stops are provided for limiting the depth of the drilling and counterboring. When operating the machine, it is simply necessary to hold the work in position and apply foot pressure to the treadle for feeding the spindles. A drip tank is provided for supplying a cooling compound to the tools when machining steel or other metals requiring a coolant.

BESLY RING-WHEEL GRINDER

Charles H. Besly & Co., Chicago, Ill., have recently placed on the market a new grinder of the ring-wheel type, which is



Large Ring-wheel Grinder built by Charles H. Besly & Co.

heavier and more powerful than any grinder heretofore built by this company. This machine, which is illustrated herewith, is equipped with two, geared lever-feed work-tables and two pressed steel ring-wheel chucks holding ring or cylinder grinding wheels 24 inches in diameter. This grinder is intended for larger and rougher work than is ordinarily done on disk grinders. The vitrified grinding rings naturally will stand

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more severe service than the emery-cloth-covered steel disk wheels. The design is massive and rigid, and the machine, as illustrated, weighs over 3500 pounds.

The geared lever-feed table weighs about 600 pounds and has a leverage of 18 to 1. The spindle pulley is 15 inches in diameter. It will take an 8-inch belt and transmits over 30 horsepower. The spindle is 3¼ inches in diameter and each bearing is 12 inches long. The rockershaft is 4½ inches in diameter and 7 feet long. The end thrust is taken on hardened and ground collars of over 20 square inches area. Each pressed steel ring-wheel chuck weighs 275 pounds and with a new grinding ring in place, weighs 415 pounds. A new grinding ring is 24 inches in diameter, 5 inches deep and has an 11-inch hole.

This machine will rough 1/16 inch stock from the bottom of a sad iron casting in about ten seconds, and the feeding pressure on the surface being ground is approximately 100 pounds per square inch of area. On a machine of this type, with hand-lever feed, the ratio of the leverage (18 to 1) is an important feature as it enables the workman, without undue exertion, to put sufficient pressure on the work to secure the maximum efficiency of the grinder. This large ratio of leverage is obtained through a gear and rack with a lever only 20 inches long. This geared motion gives the necessary table travel with a maximum ratio of leverage for the length of lever used. A longer lever would not be convenient for the workman. The lever is clamped to the pinion stud, and its position, relative to the stud, may be changed to suit the convenience of the operator.

RECENT DEVELOPMENTS IN LARGE PRESSES

A few years ago presses having more than two cranks and measuring over four or five feet between the housings, were rarely built, but at present the multiple-crank type having three or four cranks and varying in width from three to ten feet between the housings, is quite common. The accompanying engravings show several different types of large presses that have recently been built by the E. W. Bliss Co., 17 Adams St., Brooklyn, N. Y.

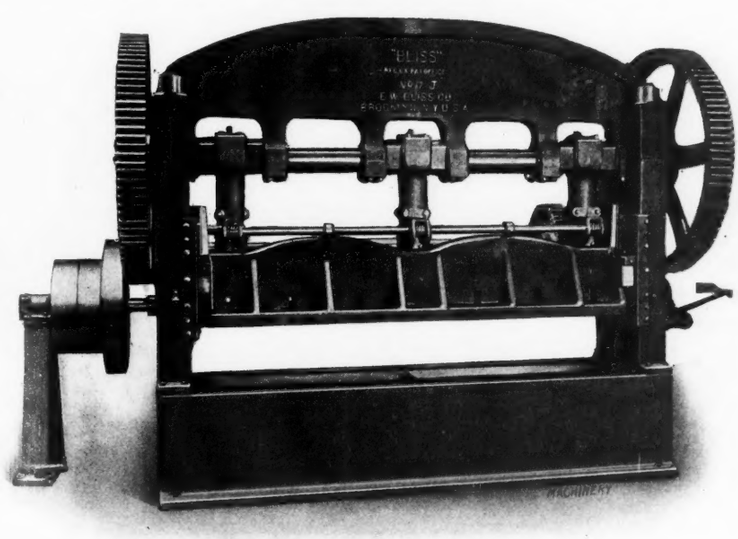

Fig. 1. Double-geared Triple-crank Press

Fig. 1 shows a multiple press having a triple crank. This machine has a width of 11 feet between the housings and a slide movement of 4 inches. Owing to the great width, it is equipped with a twin drive, a driving gear being mounted on each end of the crankshaft. This method of driving reduces the torsional strain on the crankshaft and also equalizes the pressure on the journals and gears. The action of this press is controlled by a hand-operated friction clutch. The flywheel is 40 inches in diameter and has a 6-inch face. The total weight of the machine is 59,000 pounds.

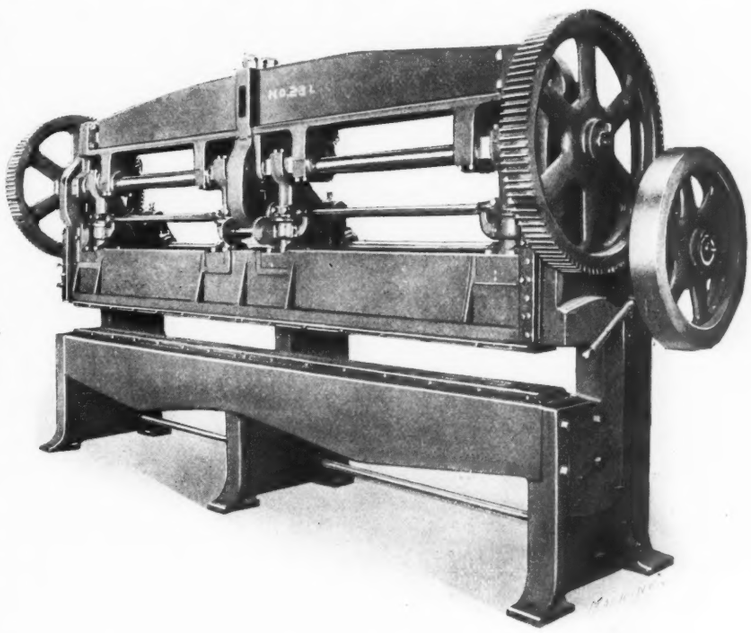

Fig. 2. Four-crank Press having Width of 14 Feet between Housings

A four-crank press is illustrated in Fig. 2. The capacity of this machine is comparatively small, but it is extremely wide, the width between the outer housings being 14 feet. The construction is of the built-up frame type with gap or overhanging housings. This press also has the twin drive, and the ratio of the gearing is 15 to 1. The crankshaft is 4 inches in diameter and has a 2-inch stroke. The flywheel weighs 600 pounds, and the weight of the complete machine is 25,000 pounds.

Fig. 3 shows a rear view of a large double-crank press. It usually takes from two to four men to operate large presses of this type, and, ordinarily, it is necessary to have at least one man back of the machine to handle the work. This is a dangerous position when the gearing is exposed and low enough to come within the workman's reach. For this reason all the large presses built by the E. W. Bliss Co. have the gearing mounted on the housings above the crankshaft, as shown in Fig. 3. With this arrangement of the driving shaft, the gearing is above the operator's head, where it is entirely out of the way. This machine and also the one illustrated in Fig. 1 are commonly known as the straight-sided, tie-rod type. The bed and crown are each a separate casting, and all the strain is taken by steel tie-rods which pass through the side housings so that the latter simply act as a guide for the slide. Machines of this type are used for blanking, forming and drawing operations on large sheets such as are used for steel range bodies, automobile parts and similar work.

The large press shown in Fig. 4 is a combination of the tie-rod and gap-frame type. The bed and crown are each a separate casting and the side housings are of box section and have a gap or opening at the front, as shown. The bed and crown are held in place by two large steel rods which pass through

the housings just back of the crankshaft and take all the strain. There are also two smaller steel rods in front of the crankshaft. These do not go below the gap and are to prevent the crown from rolling. There are also two additional rods

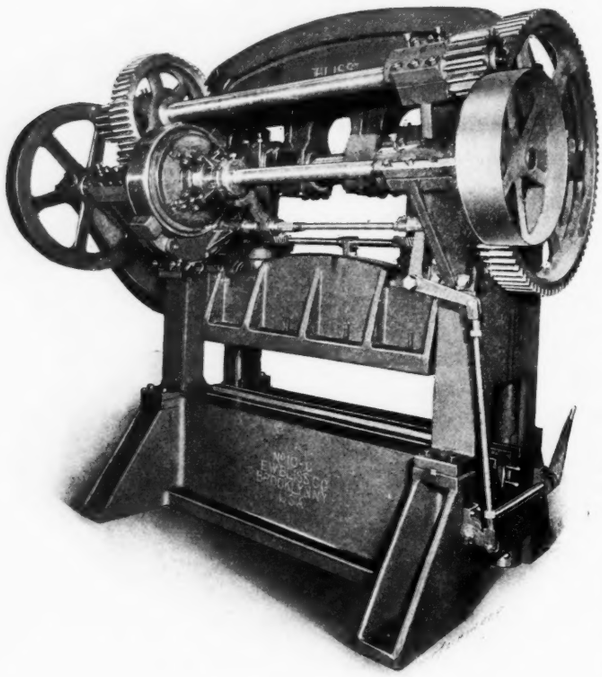

Fig. 3. Rear View of Double-crank Press

that pass through the bed and prevent the housings from springing away at the rear as they would tend to do when the main tie-rods, which pass close to the front, were shrunk in place. This construction is said to make a machine of the gap type as strong as a straight-sided press, as all the strain

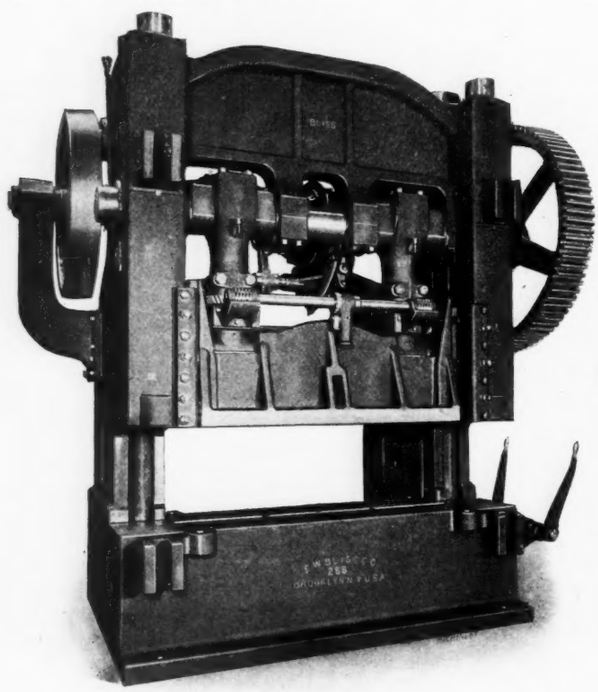

Fig. 4. Press of Combination Tie-rod and Gap-frame Type

is taken by the steel rods instead of by the cast-iron housings. This press measures 6 feet between the housings. The crankshaft is 8 inches in diameter, has a 6-inch stroke, and is driven through gearing having a ratio of 22 to 1. The flywheel is 50 inches in diameter, has a 7 inch face and weighs 1300 pounds. The total weight of the machine is 63,000 pounds.

NEW MACHINERY AND TOOLS NOTES

Light Holder: Ryede Specialty Works, Rochester, N. Y. Adjustable light holder which can readily be attached to the ceiling, wall or floor, and has universal adjustment which permits placing the light in the best position. The entire bracket is made of steel and is either nickel plated or oxidized.

Stock and Tool Trays: F. O. Weydell, 224 S. Jefferson St., Chicago, Ill. Cast-iron tool and stock trays made in different styles and sizes and intended for holding taps, drills, chisels and other tools. These trays consist of independent units which can be hung under a bench like a drawer or arranged in stacks, as required.

Shim for Bearings: Lindhe Shim Co., New York City. Shim or liner for bearings composed of a series of brass layers 0.002 inch thick which are firmly held together by a very thin film of solder. The thickness of the shim is varied by peeling off one or more layers. This shim is applicable to all classes of machinery having split bearings.

Pipe Threading Machine: Oster Mfg. Co., Cleveland, O. Machine for threading straight or bent pipe. The work is held in a swivel vise which can be adjusted to any angle for threading pipe bent to any radius from 6 to 24 inches. The vise is locked in position and the angle is shown by graduations. There is an automatic trip for cutting threads of a standard length.

Tool Grinder: W. W. Oliver Mfg. Co., 1500 Niagara St., Buffalo, N. Y. Tool grinder (No. 8) equipped with Hyatt roller bearings, which are oiled through dustproof cups. The spindle is made of machine steel accurately ground and machined, and the wheels are guarded. The height from the floor to the spindle is 38 inches, and the length of the spindle is 13⅞ inches. The net weight of the grinder is 96 pounds.

Die-plate: Scott-Rose Co., Marquette Building, Chicago, Ill. Die-plate covering a range of sizes from 3/16 to 3/4 inch. The hardened steel removable die blocks are fitted in parallel jaws. The distance between these jaws can be varied by a calibrated ratchet wheel which, through the medium of a cam, adjusts the jaws by small variations. This die-plate is 15 inches long overall, and it is furnished with U. S. standard threads unless otherwise specified.

Gas Forge: Simplex Tool & Supply Co., 125 Purchase St., Boston, Mass. Gas forge for forging or hardening lathe, planer or other tools made of carbon or high-speed steels. The width of the furnace is 10 inches and the height 8 inches. There are four burners, and 100 cubic feet of gas is consumed per hour. An air pressure of one and one-half pound is required. The advantages claimed for this forge are the facilities for watching the tool, a clean output and elimination of fusing of the tool-point.

Vertical Surface Grinder: Pratt & Whitney Co., Hartford, Conn. Vertical surface grinder which resembles the machine formerly built by this company, but is an improved design of heavier construction. It is adapted to either plain or circular grinding. A cup-shaped wheel 14 inches in diameter and 4 inches high is used. The table has a working surface 11⅝ by 36 inches, and the maximum distance from the table to the grinding surface of a new wheel is 14 inches. The machine can be equipped with a belt or motor drive.

Centering Tool: Robert H. Fay, Chicopee Falls, Mass. Centering tool for use on the lathe or hand screw machine. The body of the tool is composed of two sections which are screwed together and can be adjusted with relation to each other. The forward section carries a combination centering drill and it is beveled on the rear side to an angle of 60 degrees. The other section is in the form of a ring and is also beveled on the inside. By means of this adjustment the conical bearing can be varied to suit the angle of the lathe center, in case the latter should not be ground to the standard angle. The two sections are locked at any point by a small knurled screw.

Rolling Mill: Standard Machinery Co., Providence, R. I. Steel rolling mill designed for the cold rolling of sheet steel. The machine is driven by a sixty-horsepower motor, and there are three rolls to which power is transmitted through spur gears and cast steel herringbone pinions. The top and bottom rolls are 11 inches in diameter and have a 12-inch face. The center roll, which is known as the "baby" roll, is 5 inches in diameter and has a 12-inch face. The mill is so arranged that the 11-inch rolls can be replaced with 14-inch sizes when necessary for special work. The baby or friction roll is hardened, ground and mirror lapped. Both the 11- and 14-inch sizes are of the shell type forced over arbors, the shell part being hardened and ground tool steel. The weight of this mill is 26,470 pounds.

Crank Press: Niagara Machine & Tool Works, 639 Northland Ave., Buffalo, N. Y. Double crank-press, especially adapted to the requirements of sheet metal works manufacturing specialties of heavy and light gages. The frame is built in sections and the bed, the two housings and the arch are held together by four steel tie-rods which are shrunk in place and take the strain. Particular attention has been paid to the design of the slide cross-head and guides to adapt the

press for very accurate work. The Niagara automatic jaw clutch is used. This clutch has a safety lock which guards against accidental engagement in case the brake is not properly adjusted. The distance between the housings is 61 inches and the distance from the bed to the slide with stroke and adjustment up, is 25 inches.

Cylinder Boring Machine: Newton Machine Tool Works, Inc., Philadelphia, Pa. Special five-spindle cylinder boring machine having two uprights and a cross-rail. The right-hand upright can be shifted in or out whereas the left-hand upright is bolted to the bed. The cross-rail, which is mounted on top of the uprights, has a fore-and-aft adjustment. There are two vertical spindles on the cross-rail each having vertical and horizontal hand adjustments and a vertical feed. The left-hand horizontal spindle is mounted on a saddle attached to a knee having vertical elevation on the upright. This spindle also has a fore-and-aft hand adjustment as well as a cross-feed. The right-hand vertical saddle carries two spindles which operate in unison. This machine was especially designed for air brake cylinder work.

Safety Device: Benjamin Electric Mfg. Co., 120 S. Sangamon St., Chicago, Ill. Safety device for stamping presses which protects the hands of the operator by necessitating the removal of both hands from the point of danger in order to trip the press. The release of either hand permits the trip to return to its normal position, thus making it impossible for the press to repeat unless both hands are kept on the levers until the downward stroke begins. The operator then will not have time to get his hands back into the danger zone before the operation is completed. The device consists of an operating lever normally made inoperative, though free to move downward. This lever is made operative by an electro retaining magnet through a circuit closer. The press cannot be tripped by the operating lever unless the circuit through the magnet is first closed. This safety device can easily be applied to all standard presses.

Profiler: Pratt & Whitney Co., Hartford, Conn. Semi-automatic profiling machine capable of milling contours of practically any shape. The machine has a heavy base casting to which are bolted uprights and a cross-rail cast in one piece. The head on which the roughing and finishing spindles are mounted is clamped to the cross-rail and remains stationary when the machine is in operation. The rotary work-table is mounted on the front end of a swinging arm, journaled in the bed between the uprights. The table is actuated by worm-gearing and is provided with a change-gear mechanism by means of which any desired feed may be obtained. The table is oscillated by a cam or former under it, which is kept in contact with a roller mounted on a pin fixed to the bed. To generate this cam or former, the roller is removed and a milling cutter of the same diameter is inserted in its place. A model of the work is then mounted on the machine and a former pin of the same size as the cutter to be used, is inserted in the cutter spindle. The cam is then milled by the cutter previously referred to, which is driven independently from the main shaft.

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PERSONALS

Otto R. Winter recently opened an office at 785 Bruck St., Columbus, Ohio, as tool and machine designer.

Robert Wilde has resigned as factory manager of the R. C. H. Corporation, Detroit, Mich., manufacturer of automobile and metal products.

F. H. Brown, formerly with Chas. A. Strelinger Co., Detroit, Mich., has been made sales manager of the W. P. Davis Machine Co., Rochester, N. Y.

W. Nicholson, of W. H. Nicholson & Co., Wilkes-Barre, Pa., sailed in February for a six-week's trip in Europe in the interests of the mandrel department of his company.

Paul J. Smith, assistant foreman of the tool and die room of the Ford Motor Co.'s pressed steel plant, Buffalo, N. Y., has been promoted to the position of chief inspector.

At a meeting of the board of directors of Manning, Maxwell & Moore, Inc., New York, January 26, Mr. James B. Brady was elected vice-president in place of Mr. W. O. Jacquette.

Emory T. Smith, for a long time draftsman for the Waltham Watch Tool Co., Springfield, Mass., has resigned to take a similar position with the Chapman Valve Mfg. Co. of Springfield.

C. R. McCullough, formerly connected with the Packard Motor Car Co., Detroit, Mich., has joined the sales organization of Manning, Maxwell & Moore, Inc., and will make his headquarters in Detroit.

E. J. O'Hayer, Jr., vice-president of the Miehle Printing Press & Mfg. Co., Chicago, Ill., has taken charge of the company's office at 38 Park Row, New York, succeeding Mr. F. L. Montague, resigned.

Frank P. Smith, formerly connected with the sales office of Manning, Maxwell & Moore, Inc., New York, has again become associated with this corporation. His work will be confined chiefly to the railway department.

L. H. Mesker, who has heretofore been connected with the Cleveland branch of Manning, Maxwell & Moore, Inc., has been appointed manager of the St. Louis, Mo., branch of this corporation, succeeding Mr. C. L. Lyle. The St. Louis office is in the 'Frisco Bldg.

Howard W. Evans has taken a position with the Best Mfg. Co., Pittsburg, Pa., as general manager of sales. Mr. Evans will supervise the company's sales, order and engineering departments. He was formerly connected with the Crane Co., of Chicago, in a similar capacity.

James McCrea, president of the Pennsylvania R. R., has been appointed a member of the American Honorary Committee of the International Congress for the prevention of accidents and industrial hygiene to be held in Milan in May, 1912. The Pennsylvania R. R. only recently received a medal from the American Museum of Safety for being the American employer to do the most in the past year for the protection of the lives and limbs of its workmen.

F. W. Boye, Jr. and W. T. Emmes have purchased the interest of Mr. W. A. Schumacher in the firms Schumacher & Boye and Schumacher, Boye & Emmes, and have incorporated a new company under the name of the Boye & Emmes Machine Tool Co., to take over these two concerns. Mr. Emmes is well known in the machine tool world, having been the general superintendent of the company for a number of years. He is the inventor of improvements in quick change gear devices and other features of engine lathes.

* * *

OBITUARIES

William W. Young, purchasing agent of the Union Switch & Signal Co., Swissvale, Pa., died January 21.

S. S. Smith, of Dallas, Texas, manager of the General Fire Extinguisher Co., of Texas, died suddenly at New Orleans, January 20.

Frank D. Smith, for the past ten or twelve years traveling salesman for the Waltham Watch Tool Co., Springfield, Mass., died January 24 at his home in Springfield after a few weeks' illness, aged fifty-nine years.

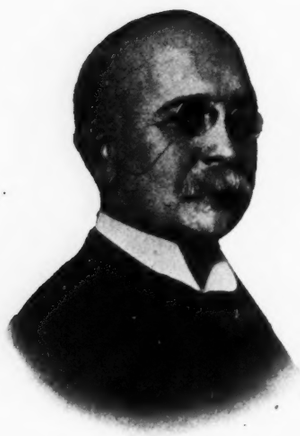
C. P. Miller, general superintendent of the Weir Frog Co., Cincinnati, Ohio, died suddenly at his office of heart failure, February 9. Mr. Miller had been connected with the company as general superintendent since 1906. He was buried at Hilburn, N. Y., his former home. He leaves a widow and three children.

Walter A. Post, president of the Newport News Shipbuilding & Dry Dock Co., Newport News, Va., died February 12, aged fifty-five years. Mr. Post was a civil engineer, and his connection with the Newport News Shipbuilding & Dry Dock Co. dates back to 1890, when he was put in charge of the erection and equipment of the plant. This work was carried out so satisfactorily that in 1898 he was made general manager. He was elected president in 1911.

S. D. Conover, a prominent citizen of Dayton, Ohio, and founder of the Miami Valley Machine Tool Co., died February 8, aged sixty-nine years. Mr. Conover was president of the company up to about a year ago when he retired from active business on account of ill-health. He was a director of the Gem City Building and Loan Association, and was interested in a number of enterprises. He leaves a widow, daughter and son, the latter being Mr. P. P H. Conover, the present head of the company.

FRANCIS H. STILLMAN

Francis H. Stillman, president of the Watson-Stillman Co., and a prominent figure in machine tool and engineering industries, died suddenly, February 18, of intestinal hemorrhage at his late residence, 105 Rodney St., Brooklyn, in his sixty-second year. The day before his death he was at his office as usual, and apparently in the best of health. Mr. Stillman was born in New York on February 20, 1850, and was graduated from Yale in the class of 1874 with the degree of B. S. He was a member of Hyatt Lodge, F. and A. M., a member of the thirty-second degree in Aurora Grata Consistory, a Knight Templar, a Noble of Kismet Temple, Mystic Shrine, and a member of the Royal Arcanum. He was a member of the Hanover Club of Brooklyn, the Engineers Club, the American Society of Mechanical Engineers, and continuously since its organization a director of the National Association of Manufacturers. He organized the Machinery Club of New York, and was its first president, and was also first president of the National Metal Trades Association. In addition to being president of the Watson-Stillman Co. at the time of his death, he was also president of the Bridgeport Motor Co., and of the Pequannock Commercial Co., and a director in other manufacturing firms. Aside from his continuous activities in various engineering organizations and projects, Mr. Stillman was one of the recognized pioneers and, perhaps, the most prominent American engineer on hydraulic machine and tool construction. On leaving college, Mr. Stillman first associated himself with the Cottrell Printing Press Co., then with his stepfather, Mr. Lyons. In 1883 he organized and became president of the



Francis H. Stillman

firm of Watson & Stillman, which succeeded Lyons & Co. The firm was incorporated in 1904 as The Watson-Stillman Co., Mr. Stillman remaining its president up to the time of his death. Under Mr. Stillman's direction, his firm early became prominent in the hydraulic engineering field, and it has built upwards of 4000 different types and sizes of hydraulic machines, and now has a large and active plant in Aldene, N. J. Mr. Stillman's kindly disposition, high standard of business integrity and kind personal interest in all those with whom he came in contact, won for him a large circle of friends that will keenly regret their loss in his death. He is survived by his widow, formerly Miss Irene A. Bancroft of Boston, and by two sons, Austin Frank and Edwin Arthur Stillman.

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COMING EVENTS

May 13-15.—Triple convention of the American Supply and Machinery Manufacturers' Association, National Supply and Machinery Dealers' Association, and Southern Supply and Machinery Dealers' Association, at Norfolk, Va., Monticello Hotel, headquarters. F. D. Mitchell, secretary-treasurer, 309 Broadway, New York.

May 14-17—Sixth annual convention of the Master Boiler Makers' Association at the Fort Pitt Hotel, Pittsburg, Pa. J. R. Flannery, of the Flannery Bolt Co., Frick Bldg., Pittsburg, Pa., secretary and treasurer of the general committee of arrangements.

June 4-7.—Spring meeting of the American Society of Mechanical Engineers in Cleveland, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York.

June 12-14.—Annual convention of the American Railway Master Mechanics' Association at Atlantic City, N. J.

June 17-19.—Annual convention of the Master Car Builders' Association at Atlantic City, N. J.

July 9—Annual convention of the American Railway Tool Foremen's Association in Chicago. H. L. Miller, secretary of the supply association, 835 Monadnock Bldg., Chicago, Ill.

August 20.—Annual convention of the International Railroad Master Blacksmith's Association at Hotel Sherman, Chicago, Ill. J. E. Carrigan, Rutland Railway, Rutland, Vt., chairman of the executive committee.

September 2-7.—Sixth congress of the International Association for Testing Materials at the Engineering Societies Building, 29 W. 39th St., New York. Mr. H. F. J. Porter, secretary, 1 Madison Ave., New York.

SOCIETIES AND COLLEGES

AMERICAN SOCIETY OF ENGINEER DRAFTSMEN, 116 Nassau St., New York, held its regular monthly meeting in the Engineering Societies Bldg., 29 West 39th St., New York, on February 15, at 8:15 P. M. The subject of the meeting was "The Training of Draftsmen," by Prof. F. G. Higbee, head of the department of descriptive geometry and drawing, Iowa State University. Mr. Wm. F. Turnbull of the engineering department of the American Locomotive Co., delivered a lecture on "Some Common Faults of Draftsmen."

NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS, Wool Exchange Bldg., 260 West Broadway, New York. The 1912 U. S. standard schedule of standard weight and extra heavy flanged fittings and flanges which was lately adopted by the joint committee on standardization of the National Association of Master Steam and Hot Water Fitters and the American Society of Mechanical Engineers. The American Society of Heating and Ventilating Engineers' special committee on standards has reported in favor of recommending its use by members of that society. Copies of the schedule will be sent to architects, mechanical engineers, heating and ventilating engineers, manufacturers, dealers, and others interested, without cost, upon receipt of request.

INVENTORS GUILD, Ralph D. Mershon, 60 Wall St., N. Y., president, has addressed a resolution to President Taft regarding inadequate patent protection given to American inventors. The substance of the resolution is that a patent is in effect a contract between the government and the inventor, by which the government in consideration of the right to publish the invention agrees to secure to the inventor for a limited time the exclusive right to use his invention, and that under present conditions these rights are not properly safeguarded. Under existing methods of trying patent causes, an inventor-patentee of average means cannot at his own expense carry to a conclusion a patent litigation against a wealthy opponent, and, therefore, a few wealthy concerns have acquired many important patents in their field, to the great damage of the nation, because of the restraint of competition and because of the resulting tendency of such inventors to seek protection for their inventions by keeping them trade secrets, or by ceasing to develop inventions.

NEW BOOKS AND PAMPHLETS

YEAR BOOK OF THE AMERICAN ELECTRICAL INSTITUTE, 1912. F. L. Hutchinson, secretary, 23 West 39th St., New York.

THE VERMONT BULLETIN. Catalogue 1911-1912. 190 pages, 5 by 7½ inches. Published by the University of Vermont and State Agricultural College, Burlington, Vt.

THE KINGDOM OF DUST. By J. Gordon Ogden. 116 pages, 4¼ by 7 inches. Numerous halftone illustrations. Published by Popular Mechanics Co., Chicago, Ill. Price 50 cents.

COMPARATIVE RAILWAY STATISTICS OF THE UNITED STATES, UNITED KINGDOM, FRANCE AND GERMANY. Published as Bulletin No. 24, by the Bureau of Railway Economics, Washington, D. C.

NEW HAMPSHIRE HIGHWAYS. Report of an Inspecton of Highways in the State of New Hampshire, August, 1911. By Charles H. Hoyt. Published by U. S. Department of Agriculture, Washington, D. C.

PROCEEDINGS OF THE AMERICAN ELECTRIC RAILWAY ENGINEERING ASSOCIATION, 1911, containing a complete report of the ninth annual convention held at Atlantic City, N. J., October 9-13, 1911. H. C. Donecker, secretary-treasurer, 29 West 39th St., New York.

THE MODERN SUBMARINE BOAT. Chart 14 by 28 inches. Published by Norman W. Henley & Son, New York. Price 25 cents.

This chart is printed on heavy paper, suitable for framing, and contains a cross-section showing clearly and distinctly the interior parts of a modern submarine boat. Two hundred parts are numbered and named in a reference list printed alongside of the illustration. The chart is drawn accurately to scale.

THE ESSENTIALS OF LETTERING. By Thomas E. French and Robert Meiklejohn. 94 pages, 9 by 6 inches. 119 illustrations. Published by McGraw-Hill Book Co., New York. Price $1.00.

This is the third edition of a manual on lettering for students and designers. Like the previous editions, it contains an outline on the history of lettering, and then contains chapters on letter construction, composition and titles, selection of styles, letters in design, design and composition, monograms, ciphers and marks, and on drawing for reproduction.

ENGINEERING DIRECTORY. 1496 pages, 4 by 6¾ inches. Published by D. Crawford Publishing Co., Chicago, Ill. Price $5.00.

This is the 1912 edition of this well-known directory, now in its nineteenth year of publication. In the classified section, manufacturers' products are found under 3850 classifications. The directory contains the names of more than 6000 manufacturers, producing over 4000 varieties of engineering goods and having more than 50,000 trade or brand names. The book is bound in leather and has thumb indexes to its fifteen sections.

HAND FORGING AND WROUGHT-IRON ORNAMENTAL WORK. By Thomas F. Googerty. 197 pages, 5¼ by 8 inches. 122 illustrations. Published by Popular Mechanics Co., Chicago, Ill. Price $1.00.

This book has been written in order to meet the demand for an inexpensive text-book on the subject of hand-wrought ornamental iron work. It contains numerous examples of ornamental forging, giving explicit directions for doing the work. It contains twelve chapters headed as follows: Introductory; Equipment; Working at the Forge; Various Forms of Welding; Welding (Concluded); Twisting, etc.; Scrollwork; Box Forging; Embossing; Drawer-pulls and Hinges; Doorplates; Iron Lamps.

AN INVESTIGATION OF THE STRENGTH OF ROLLED ZINC. By Herbert F. Moore. 24 pages, 6 by 9 inches. 14 illustrations. 13 tables. Published by the University of Illinois, Urbana, Ill. Price 15 cents.

This bulletin, No. 52 of the Engineering Experiment Station of the University of Illinois, records the results of tests made in the laboratory of applied mechanics of the University on the tensile, compressive and shearing strength of zinc. Comparison is made with results of tests made in Europe. The resisting power of the zinc to stress is shown to be from 30 to 40 per cent of that of soft steel. While normally sold at a price of 15 cents, copies of the bulletin may be obtained free of charge upon application to Prof. W. F. M. Goss, University of Illinois, Urbana, Ill.

EFFICIENCY AS A BASIS FOR OPERATION AND WAGES. By Harrington Emerson, 256 pages, 5 by 7½ inches. Published by the *Engineering Magazine*, New York. Price $2.00.

This is the third edition of this work. It has been revised and enlarged, but, of course, the subject matter is in the main the same as in the previous editions. While, as the author says, when the first edition was brought out, it was almost as the voice of one crying in the wilderness, with a new doctrine and an unusual form of teaching it, the subject is now fairly familiar to the engineering world. The main changes in the third edition consist in the revision which has been due to the rapid change of public sentiment, and the enlargement of the text designed principally to emphasize certain points upon which experience has shown added emphasis to be necessary.

PREVENTION OF RAILROAD ACCIDENTS OR SAFETY IN RAILROADING. By George Bradshaw. 173 pages, 4½ by 6½ inches. Numerous illustrations. Published by Norman W. Henley & Son, New York. Price 50 cents.

The author of this book, a practical railroad man, has for ten years been constantly engaged in the investigation and settlement of claims for personal injuries and death resulting from railroad accidents. This direct experience gives his work especial value. The book is addressed especially to railway employes and is, therefore, confined to that class of accidents that are within the power of the employes to prevent by their own personal efforts. The illustrations in the book show in a graphical manner how dangers may be avoided in railroading, and illustrate also the careless methods which are the cause of many accidents. The book is of considerable interest even to non-railroad men, and some of the general sections would be useful to anyone in the mechanical trades.

TWELVE PRINCIPLES OF EFFICIENCY. By Harrington Emerson. 423 pages, 5 by 7½ inches. Published by the *Engineering Magazine*, New York. Price $2.00.

The earlier book—"Efficiency as a Basis for Operation and Wages"—by the same author, was essentially the statement of a philosopher. It contains a new view of the industrial problem and defines the relations and proportions of the factors that enter into it. This latter volume is in a sense a continuation of the earlier work, but it is more specific in its statements and reduces the doctrine of efficiency to a practical basis. The twelve principles of efficiency the author enumerates are as follows: Clearly defined ideals; common sense; competent counsel; discipline; the fair deal; reliable, immediate and adequate records; despatching; standards and schedules; standardized conditions; standardized operations; written standard practice instructions; and efficiency reward. The book contains a great many examples from practice indicating possibilities for improved efficiency and makes altogether interesting reading even if one should not everywhere agree with the conclusions of the author. On many important questions the author, although at odds with the trend of the times, undoubtedly strikes the true keynote of efficiency, as for example when he scores the great terminal stations of railroads as monuments of inefficiency, and shows that they are lacking in the application of true engineering principles.

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Spindle Speeds Up to 1000 Revolutions Per Minute Meet the Demands of Drilling, Die Sinking and Similar work on the

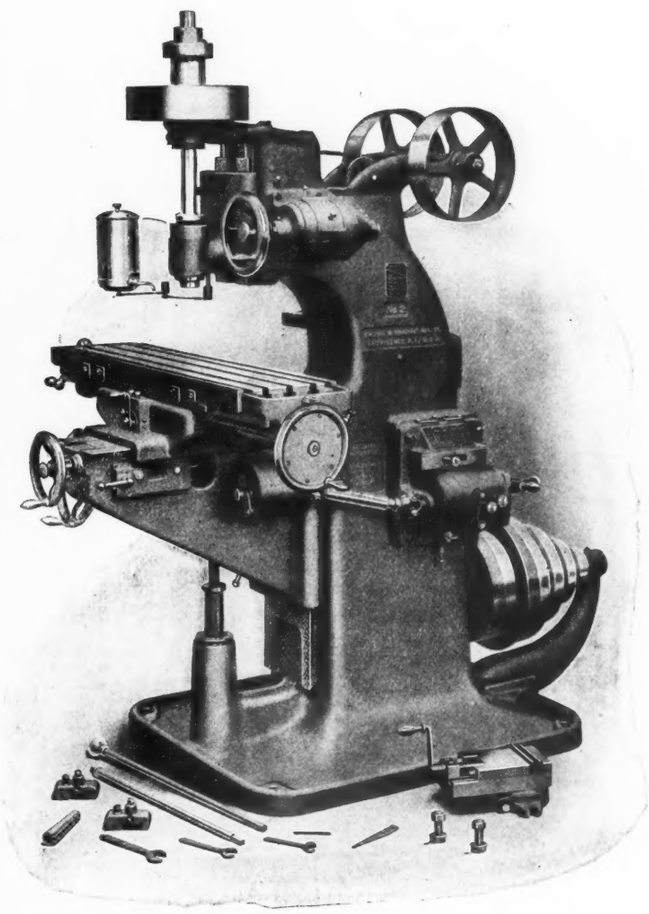
No. 2 Vertical Spindle Milling Machine

And with a *High Speed Milling Attachment*, a large variety of much faster speeds is obtainable for work where higher speeds are required. This feature, coupled with the accuracy, simplicity and convenience of this machine, makes it a valuable tool for every shop.

Other attachments for this Machine:

In addition to the *High Speed Milling Attachment* mentioned above, we can furnish a *Circular Milling Attachment* and *Horizontal Milling Attachment.* The variety of work that can be done on this machine when equipped with all three attachments is exceedingly great.

This is just the machine to complete the equipment of your shop.



Send for a special circular giving description and full specifications.

BROWN & SHARPE MFG. CO.

PROVIDENCE, R. I., U. S. A.

STREET LIGHTING. By J. M. Bryant and H. G. Hake. 61 pages, 6 by 9 inches. 28 illustrations. Published by the University of Illinois, Engineering Experiment Station, Urbana, Ill., as Bulletin No. 51.

Efficient and economical street lighting is a subject on which little information of a definite and tangible character has been published. Bulletin No. 51 is designed to supply such information concerning electric street lighting. The subject has been treated in a simple, direct manner, and while of especial interest and value to the technically trained illuminating engineer, will appeal particularly to city councils and central station managers. The general theory and construction of electric lamps, both incandescent and arc, are discussed together with the standard systems of electric distribution for lighting, and accepted methods for the measurement and study of illumination, with and without shades and reflectors. These principles are then applied to the study of street illumination, curves and calculations being given to show the candle-power distribution for the various lamps used, equipped with their proper glassware and reflectors, and others to show the illumination along the street for representative installations and conditions. Based upon these results, a discussion is given of the proper lighting of business streets, cross streets, boulevards, residence streets and outlying districts. The subject of economy for the several systems and lamps is discussed—the initial cost, up-keep, interest, and depreciation of various lamps and equipment are considered in tables and curves showing their relative economy at standard costs of power. Attention is also called to the economical selection of different lamps for certain classes of illumination.

NEW CATALOGUES AND CIRCULARS

WALTER O. AMSLER, Pittsburg, Pa. Descriptive pamphlet of the Amsler gas producers and accessories.

UNITED NUT LOCK CO., Springfield, Mass. Leaflet advertising the "Hugtite" nut lock manufactured by the company.

EMERSON ELECTRIC MFG. CO., St. Louis, Mo. Catalogue of Emerson fan motors for alternating and direct currents.

ROBBINS CONVEYING BELT CO., New York. Bulletin No. 48 on chains, sprockets and elevators; Bulletin No. 49 on conveyor belts.

HARVEY HUBBELL, INC., Bridgeport, Conn. Folder advertising the Hubbell lamp guard, a wire guard for protecting the bulbs of electric lamps.

CALCULAGRAPH CO., 9 Maiden Lane, New York. Circular on the advantages of the calculagraph for registering actual working time in shops, mills, factories, etc.

NATIONAL TUBE CO., Pittsburg, Pa. Bulletin No. 8 treating of the necessity for protecting pipe with a coating material, and giving suggestions relating to the laying of pipe covered with "National" coating.

SPRAGUE ELECTRIC WORKS OF THE GENERAL ELECTRIC CO., 527 W. 34th St., New York. Catalogue No. 325 of Sprague electric fans, illustrating and describing the various types of fans made by the company.

FAWCUS MACHINE CO., Pittsburg, Pa. Booklet on worm gearing, containing a general outline of the requirements of worm-gearing installations, and tables of standard worm-gearing manufactured by the company.

CHICAGO PNEUMATIC TOOL CO., Chicago, Ill. Bulletin No. E-19 on universal electric drills operating on direct or alternating current; bulletin No. E-20 on a new line of electric drills for heavy duty for direct current.

PAWLING & HARNISCHFEGER, Milwaukee, Wis. Folder illustrating "P. & H." apparatus for steel mills, rolling mills, foundries, etc., comprising grab buckets, charging machines, mono-rail systems, mill type cranes, etc.

NATIONAL TUBE CO., Pittsburg, Pa. N. T. C. bulletin No. 4 on "Corrosion of Boiler Tubes," by Rear Admiral John D. Ford, U. S. N., being an abstract of a paper published in the journal of the American Society of Naval Engineers, May, 1904.

ELECTRO-DYNAMIC CO., Bayonne, N. J. Circular No. 39, entitled "Ratings and Dimensions of Inter-Pole Constant and Adjustable Speed Type 'S' Motors." The circular, which covers 24 pages, is principally devoted to tables giving this information.

ELECTRIC CONTROLLER & MFG. CO., Cleveland, Ohio. Bulletins No. 1017, on automatic controllers; No. 1018, motor field rheostats; No. 1019, protective panels for direct-current motors; No. 1020, automatic float switch; No. 1021, motor starting rheostats.

UEHLING INSTRUMENT CO., Passaic, N. J. Bulletin No. 102 on recording instruments, describing a line of recorders for pressures up to 30 pounds per square inch. These instruments are calibrated either in ounces, pounds, inches of water or mercury.

SEAGER ENGINE WORKS, Lansing, Mich. 1912 catalogue of Olds gasoline and kerosene engines. Various types of engines from the smallest sizes up to 70 H. P., intended for miscellaneous uses—for small power plants as well as for agricultural work—are illustrated and described.

LINK-BELT CO., Philadelphia, Pa. Circular illustrating application of the "Maximum" silent chain to automobile engines. The illustrations show the "Maximum" chain applied to driving the magneto, pump and camshaft, thus eliminating all toothed gearing in mesh and reducing the gear noise.

WESTERN TOOL & MFG. CO., Springfield, Ohio. Catalogue of shop furniture comprising portable vise stands, tool stands, lathe stands, stands for blacksmith and machine shops, assembling stands, driving block stands, steel racks, power hacksaws, bench legs, drill holders, emery wheel dressers, etc.

THOMAS E. BUTTERFIELD, consulting engineer and gas power specialist, 68 William St., New York. Circular indicating the work which Mr. Butterfield is prepared to undertake, such as testing gas and oil engines and producers, designing of gas engines and producers, building, equipping and organizing new shops, etc.

LEXINGTON INSTRUMENT WORKS, Lexington, Ohio. Bulletin No. 1 on the Smith recording gas calorimeter, type A. This instrument is designed to supersede the ordinary type of calorimeter which requires the services of a skilled chemist in order to get satisfactory results. The Smith calorimeter will give reliable results in the hands of the ordinary plant operator.

GENERAL ELECTRIC CO., Schenectady, N. Y. Bulletins No. 4887, on small turbo-generator sets from 5 K.W. to 300 K.W.; No. 4900, on series incandescent lighting apparatus; No. 4918, on direct-current switchboards; No. 4919, on small plant direct-current switchboards; No. 4920, on GE-203A railway motor; and No. 4924, on Thomson prepayment watthour meters.

SMITH-BOOTH-USHER CO., 228-238 Central Ave., Los Angeles, Cal. Catalogue A of machinery, supplies, pipe and fittings, comprising equipment for pumping and irrigation plants, power plants, distillate engines, steam boilers, steam engines, air compressors, transmission machinery, machine tools, woodworking machinery, mining machines, concrete and brick machinery, etc.

GEORGE J. HENRY, JR., hydraulic and mechanical designing and constructing engineer, Rialto Bldg., San Francisco, Cal. Booklet entitled "Water Power," giving hints as to its economical and efficient development and use for hydro-electric transmission for mining and industrial plants, and containing miscellaneous information relating to hydraulic power plant developments.

B. F. STURTEVANT CO., Hyde Park, Mass. Catalogue No. 190 on Sturtevant steam turbines illustrating and describing the new slow-speed type particularly adapted for direct connection with blowers, ventilating fans, gas exhausters, mechanical draft installations, electric generators, centrifugal pumps, and other apparatus for which efficient turbine speeds have generally been too high.

NATIONAL ELECTRIC WELDER CO., Warren, Ohio. Circular of the National spot welder, which in the 24-inch size will weld to the center of a 48-inch shape and unite two ⅜-inch pieces of boiler plate. The machine has a capacity of thirty spot welds per minute in 1/16-inch sheet steel and twenty per minute in ⅛-inch sheet steel. The company makes both spot and butt welding machines.

LANGELIER MFG. CO., Providence, R. I. Bulletin No. 28-32 on Langelier multiple drilling machines with three interchangeable heads. These heads embody the well-known Langelier design of multiple spindles with cranks driven by a common crank plate on the main spindle. The design of drilling head enables the maker to place spindles in any desired relation and at a minimum distance apart.

FITCHBURG STEAM ENGINE CO., Fitchburg, Mass. Pamphlet on the Fitchburg plan of industrial education by Mr. W. B. Hunter, director of the industrial department of the Fitchburg high school. All who are interested in industrial education should procure copies of this pamphlet which describes the successful Fitchburg plan of educating boys in the high school and the shops simultaneously.

CORK INSERT CO., 16 State St., Boston, Mass. Booklet entitled "Here's the Proof," containing a number of letters from customers of the company, giving the results obtained from cork-insert installations; also folder entitled "Relative Cost per H. P. transmitted by means of Plain and Cork-Insert Pulleys." This folder contains a diagram to illustrate the comparison, and tabulated cost estimates.

SIDNEY C. CARPENTER, Box 191, Plainville, Conn. Binder with sheets of engineering data useful to draftsmen, designers, mechanical engineers, and others concerned with the design, construction and use of machinery. These data sheets comprise weights and measures, steam engines, air brakes, pay-rolls, drafting-room conventions, machine shop work, machine design, etc. Prices given upon application.

HINCKLEY MACHINE WORKS, Hinckley, Ill. Circular of the Davis milling attachment and compound table for drilling machines, consisting of a circular base carrying a saddle on cross-slides which are operated by screws having balanced handles. The circular illustrates the use of the attachment showing how any upright drill press from 14 inches to 42 inches swing can be converted into a vertical milling machine.

WHEELER CONDENSER & ENGINEERING CO., Carteret, N. J. Booklet entitled "Steam Tables for Condenser Work." This is a hand-book of steam tables with pressures below atmosphere expressed in inches of mercury referred to a 30-inch barometer. It also includes a discussion of the use of the mercury column. None of the tables given have ever been published before, but have been calculated especially for this book.

GENERAL ELECTRIC CO., Schenectady, N. Y. Bulletin No. 4893, describing automatic time switches; No. 4901, on alternating-current switchboard panels; No. 4904, on small plant alternating-current switchboard; No. 4905, on small plant alternating-current switchboards; No. 4906, on the lighting of textile mills with Edison Mazda lamps; No. 4907, on the lighting of offices, banks and public buildings; No. 4917, on direct-current exciter panels.

FERRO MACHINE & FOUNDRY CO., Hubbard Ave. and E. 66th St., Cleveland, Ohio. Catalogue of "Ferro" gasoline engines, including a practical treatise on the subject. This handsome publication will be found of general interest by all concerned with the use and operation of gasoline engines, being fully illustrated and showing details of construction throughout. The catalogue illustrates the company's line of marine engines for launches and power boats.

JAMES CLARK, JR., ELECTRIC CO., Louisville, Ky. Catalogue of "Willey" electrically driven tools, dynamos and motors, comprising portable drills for alternating or direct current in a variety of styles; lathes, center grinders, suspended surface grinders, buffers and bench grinders, water tool grinders, wet and dry grinders, sensitive bench drills, upright floor drills, two and three spindle drills, radial drills, notching presses, winding machines, etc., all electrically driven.

MORTON MFG. CO., Muskegon Heights, Mich. Catalogue of draw-cut shapers and keyseating machinery, comprising bulletins Nos. 1, 2, 3, 4, 5, 6 and 7 on keyseating machines, portable planers and portable keyseaters, standard pillar draw-cut shapers, 26-inch stroke draw-cut shaper with rod brass and shell planing attachments, 30-inch stroke shaper with rod brass shell planing and parallel shoe and wedge attachments, special railroad draw-cut shaper and traveling head draw-cut cylinder planers with full equipment.

V & O PRESS CO., Glendale, Brooklyn, N. Y. Bulletin No. 6 illustrating and describing automatic attachments for power presses; bulletin No. 1A on inclinable presses; and bulletin No. 200 on sheet metal working machinery. The latter bulletin describes several types of sheet metal working machines which supplement the ordinary press and die equipment of manufacturers of sheet metal articles, such as small automatic screw machines, knurling machines, hand wire ring machines, beading and flanging machines, draw benches, and rolling machines.

WESTINGHOUSE ELECTRIC & MFG. CO., East Pittsburg, Pa. Folder No. 4222, on economy coils for tungsten display lighting; descriptive leaflet No. 2299-A, on Westinghouse type HF slip ring induction motors; leaflet No. 2386, on alternating current heavy duty type MW slip ring induction motors; leaflet No. 2387, on type MS alternating current elevator motors; leaflet No. 2390, on type E alternating current generators for engine drive; leaflet No. 2389, on type G alternating current generators for belt drive; and folder 4213, on oil circuit breakers.

ARMSTRONG MFG. CO., 297 Knowlton St., Bridgeport, Conn. Catalogue showing the company's full line of pipe threading machines and parts. The catalogue comprises 45 pages, 6 by 9 inches. An interesting feature of this catalogue is that every detail that enters into the manufacture of this company's machines is illustrated and either lettered or numbered, so that a customer can order duplicate parts directly from the catalogue, and can thus replace broken or worn parts without delay, which is an extremely important feature in the case of a breakdown.

NEW DEPARTURE MFG. CO., Bristol, Conn. Catalogue of ball bearings containing 76, 6 by 9 inch pages, giving information of a technical character relating to ball bearings, well illustrated with high-grade engravings. The book treats of the double row, the single row, and the "radax" type of ball bearings, and describes the accurate methods for testing used in the company's plant. The greater part of the catalogue is given over to concise descriptions of the application of ball bearings and suggestions for their proper use. A number of useful tables are included.

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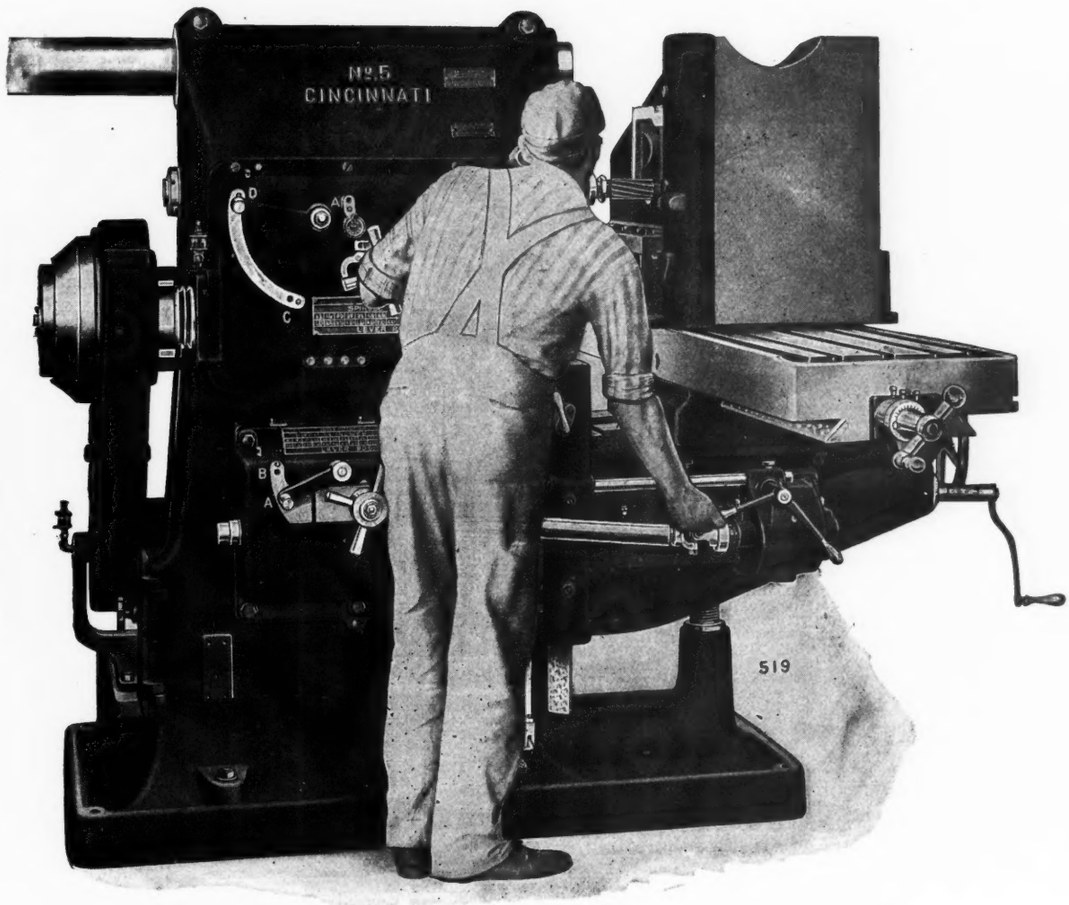
Cincinnati Handiness



WHEN you have a job of end or face milling to do on a Horizontal Miller, don't you find it hard to operate the feed lever and at the same time keep your eye on the cutter? That's because the machines you are using can be operated from only one place. Our new High Power Machines have an additional feed lever at the side of the knee.

The operator can stand close up to his work, with the cutter in full view, and control the machine from this position.

With this one lever he can operate and reverse table, cross or vertical feeds.

The main starting lever is immediately in front of him and the speed and feed changers are at his elbow, so that the entire machine is under complete control from here. *Ask for the catalog.*

The Cincinnati Milling Machine Company

Milling Specialists **CINCINNATI, OHIO, U.S.A.**

EUROPEAN AGENTS—Alfred H. Schutte, Cologne, Berlin, Brussels, Milan, Paris and Barcelona. Donauwerk Ernst Krause & Co, Vienna, Budapest and Prague. Sam Lagerlofs, Stockholm, Sweden. Axel Christiernsson, Abo, Finland. Chas. Churchill & Co., London, Birmingham, Manchester, Newcastle-on-Tyne and Glasgow. CANADA AGENT—H. W. Petrie, Limited, Toronto, Montreal and Vancouver. AUSTRALIAN AGENTS—Thos. McPherson & Son, Melbourne. JAPAN AGENTS—Andrews & George, Yokohama. CUBA AGENT—Krajewski-Pesant Co., Havana. ARGENTINE AGENTS—Robert Pusterla & Co., Buenos Ayres.

MARVIN & CASLER CO., Canastota, N. Y. Catalogue of the Marvin & Casler offset boring tool for lathes, milling machines, drilling machines, boring machines, etc. The tool is graduated to 0.001 inch and provision is made for holding the adjustment so that the tool stays where it is set. The catalogue is illustrated with examples showing uses of the tool that will suggest other uses to interested persons. The tool is made in five sizes, the small size having offset capacity of 3/16 inch and drill chuck capacity of 1/2 inch, and the large size 5/8 inch and 1 1/2 inch respectively.

T. B. WOOD'S SONS CO., Chambersburg, Pa. Catalogue No. 55 entitled "Modern and Approved Appliances for the Transmission of Power." This catalogue comprises 242 pages, 6 by 9 inches, and is substantially bound. It lists a complete line of power transmission appliances with dimensions and price lists, and includes shafting, shaft collars, flange or plate couplings, double cone compression couplings, Collins compression couplings, clutch couplings, hangers and hanger bearings, pillow blocks, belt shifting appliances, countershafts, pulleys, belt tighteners, friction clutches, rope sheaves, etc.

VEEDER MFG. CO., 39 Sargeant St., Hartford, Conn. Catalogue of the Veeder products, including the Veeder hub odometer or mileage recorder for trucks, automobiles or taxicabs; the Veeder tachodometer, which is a combination of speed indicator and mileage recorder; cyclometers for bicycles and motor cycles; the Veeder counters for different purposes; revolution counters for finding the revolutions per minute made by a shaft or any other revolving part; and printing press counters and tachometers. The catalogue gives complete descriptions of the various instruments and their use and care. It also includes illustrations and descriptions of die castings, which this firm makes for the trade.

NORTON CO., Worcester, Mass. 1912 edition of catalogue of grinding wheels and machinery, listing the Norton products, including alundum grinding wheels, crystolon grinding wheels, alundum grain for polishing, crystolon grain for polishing, India oilstones, crystolon sharpening stones, glass cutting wheels, razor hones, scythe stones, Norton alundum refractories, Norton valve grinding compound, rubbing bricks and stones, grinding wheel dressers, and grinding machinery. The catalogue comprises 142 pages, 6 by 9 inches, and shows excellent illustrations of all the products of the company. It also contains considerable information of a general nature, useful in the grinding department of a machine shop.

MORSE TWIST DRILL & MACHINE CO., New Bedford, Mass. Catalogue of increase and constant angle twist drills, reamers, chucks, milling cutters, taps, dies, machinery and machinists' tools. This catalogue for 1912 is the largest and most comprehensive catalogue issued by the company. The alphabetical index of contents covers nearly seven and one-half pages, and the index by numbers nearly six and one-half pages. The two indexes make the finding of any desired article an easy matter. Tables and data which conclude the catalogue are of general value to users of machine tools, and the catalogue will be of general interest and value to superintendents, foremen, machinists, toolmakers, apprentices, etc.

CARLYLE JOHNSON MACHINE CO., Manchester, Conn. Booklet entitled "The Johnson Friction Clutch as Applied in Machine Building," showing illustrations of well-known machine tools in which the Johnson clutch is being successfully used. The illustrations comprise the Newton horizontal milling machine, Betts vertical boring mill, Gridley multiple spindle automatic screw machine, Beaman & Smith quick operating vertical spindle milling machine, J. E. Snyder & Son's upright drill, Merrell Mfg. Co's pipe threading machine, Fay Machine Tool Co's automatic turning lathe, National-Acme Mfg Co's automatic screw machine, etc. The booklet illustrates the construction of the clutch, showing its compactness and simplicity.

CRESCENT MACHINE CO., 56 Main St., Leetonia, Ohio. Catalogue No. 51 of the Crescent universal wood-worker which comprises a band saw, jointer, shaper, saw table and borer in one machine. It is not, however, a combination in the sense of a single machine that can be adapted for different uses, but is a combination of machines each independent of the other, arranged compactly and self-contained so that all can be driven by one main belt from the lineshaft. It is not necessary to run more than one machine when only one is in use, but four persons may use different machines at the same time without hindrance. The value of a machine of this compact arrangement for pattern shops and other places where space is limited, is obvious.

CHARLES H. BESLY & CO., 118 N. Clinton St., Chicago, Ill. Catalogue of Besly spiral disk grinders, band polishing machines, "Helmet" spiral circles, etc. The growth of the disk grinder business is strikingly shown by this catalogue of 112 pages. It has been necessary to index the different types of grinders, covering their general purposes, the divisions being single spindle, belt-driven machines; single spindle, motor-driven machines; double spindle, belt-driven machines; vertical spindle and special grinders, and patternmakers' disk grinders. It has been the aim to make the catalogue answer any reasonable question, and not only is full information given in connection with each machine, but also detailed dimensions, weights, etc., of disk wheels, ring wheel chucks, various types of floor presses, work tables, countershafts, fixtures, accessories, etc.

HEALD MACHINE CO., 20 New Bond St., Worcester, Mass. Booklet "Oversize Standards for Pistons and Rings," by Mr. James N. Heald, being a reprint of a paper presented at the summer meeting of the Society of Automobile Engineers, June, 1911. The author advocates establishing certain oversize standards for automobile pistons and rings, the object being to enable automobile engines to be refitted with new pistons at low cost. If worn automobile cylinders are bored or ground under present conditions it is necessary to make patterns for new pistons, and to fit the pistons up from the rough castings. The automobile manufacturers should provide oversize pistons as they have the jigs, fixtures and patterns that can be easily adapted to the oversize requirements. The oversizes suggested are 0.010, 0.020 or 0.050 inch more than the standard sizes. With these sizes in stock a repair man could regrind an auto cylinder and fit it with a new piston and rings in short time and at small expense.

TRADE NOTES

MUMFORD MOLDING MACHINE CO., Plainfield, N. J., reports the sale of a large 24-inch jolt reamer, having a capacity of 24,000 pounds, to the Canadian Rand Co., Sherbrooke, Quebec, Canada.

STARK ROLLING MILL CO., Canton, Ohio, has furnished a large amount of formed sheet metal of anti-corrosive "Toncan" metal for the United States coaling station at Pearl Harbor, Hawaii.

WESTINGHOUSE AIR BRAKE & TRACTION BRAKE CO., has removed the office of its southeastern manager, Mr. R. A. Craig, from the general office Wilmerding, Pa., to 308 Westinghouse Bldg., Pittsburg, Pa.

ADAMS-BAGNALL ELECTRIC CO., Cleveland, Ohio, manufacturer of electric light apparatus specializing on electric lighting systems for industrial plants, is now located in its new factory at 7125 Platt Ave., S. E., Cleveland.

RUGGLES-COLES ENGINEERING CO., 50 Church St., New York, reports that the Bayonne Casting Co. has just cast the second propeller for one of the Japanese battleships. These propellers, each of which weighs approximately 12,000 pounds, are to go to the Fore River Ship-Building Co. for finishing and will then be sent to Japan.

H. W. JOHNS-MANVILLE CO., has moved its Pittsburg office from Liberty Ave. above Ninth St. to the eight-story stone, reinforced concrete and steel building at the northeast corner of Wood St. and First Ave. The company has leased the entire building for a term of years and will occupy the whole of it. The building is 31 by 96 feet and contains a gross floor space of approximately 23,800 square feet.

H. W. JOHNS-MANVILLE CO., 100 William St., New York, has acquired the sole selling agency for the Frink reflectors and illuminating specialties. The company is already known in the illuminating field by reason of its J-M linolite system of illumination and will now be in position to design and sell lighting systems for every known form of artificial illumination. An extensive engineering department will be maintained.

STANDARD ELECTRIC TIME CO., a Connecticut corporation formerly located at Waterbury, Conn., and now temporarily located at Foxboro, Mass., will move to its new factory building on Logan St., Springfield, Mass., in April. The general office of the company, which has been in Boston, Mass., will also be transferred to Springfield. Mr. George L. Riggs is president and general manager, and Mr. G. F. Harter, works manager.

BEST MFG. CO., Pittsburg, Pa., has equipped its new plant to expeditiously fill all orders for piping of every description. It is prepared to lay out entire piping systems, furnish material cut and fitted ready for erection, or to take contracts and install complete, ready for operation. Mr. H. W. Evans, formerly with the Crane Co., Chicago, is general manager of sales in charge of the sales, order and engineering departments.

BOYE & EMMES MACHINE TOOL CO., Cincinnati, Ohio, is the successor of Schumacher & Boye and Schumacher, Boye & Emmes. Mr. F. W. Boye, Jr., and W. T. Emmes have purchased the interest of Mr. W. A. Schumacher in both firms. Mr. Emmes has been connected with the firm for a number of years and has a wide reputation in the mechanical line. The firm of Schumacher & Boye has been in existence for about fourteen years.

H. B. BROWN CO., East Hampton, Conn., recently had an important change in personnel of its officers. Prof. Charles S. Brown has acquired a controlling interest, and has been made president; Abner W. Barton is secretary and treasurer; and Henry B. Brown, the late president, after forty-six years of continuous and successful labor, retires from active duty. The company manufactures bolt and nut machinery, and its product is well known throughout the world.

VERMONT MACHINE TOOL CO., Windsor, Vt., has been incorporated to manufacture a multiple-spindle automatic turret drilling machine, designed by Mr. G. O. Gridley of the Windsor Machine Co. In addition to the advantages of the usual type of multiple-spindle drill, this machine is fully automatic in its action, so that its output is not dependent upon the personal element of the operator, and it has in addition certain features in common with the turret machines.

NEIL MACHINERY CO., successors to Geo. E. Neil, machine tool dealer, has opened large display rooms at 711-713 St. Clair Ave., N. E., Cleveland, Ohio, and will handle a line of machine tools. The company will represent, among other concerns, the Springfield Machine Tool Co., Springfield Ohio; Oliver Machinery Co., Grand Rapids, Mich., and the Waterbury, Farrel Foundry & Machine Co., Waterbury, Conn. Mr. Neil was for a long time connected with the W. M. Pattison Supply Co., but has been doing business for himself for the past three years. The company is open for arrangements for agencies in non-competing lines.

LEA EQUIPMENT CO., manufacturer of high-duty centrifugal pumping equipment and the "Lea-Simplex" cold saws, which has heretofore had general offices at 97 West St., New York, has found it necessary to enlarge its manufacturing facilities to accommodate its extensive and growing trade by removal to the works at the corner of Stenton and Wyoming Aves., Philadelphia. The general sales offices will be located at the works under the supervision of Mr. H. R. Williams, the general sales manager. The company will retain quarters in the West St. building, New York, from which point the export and Eastern trade will be served by the president, Mr. Albert G. Lea.

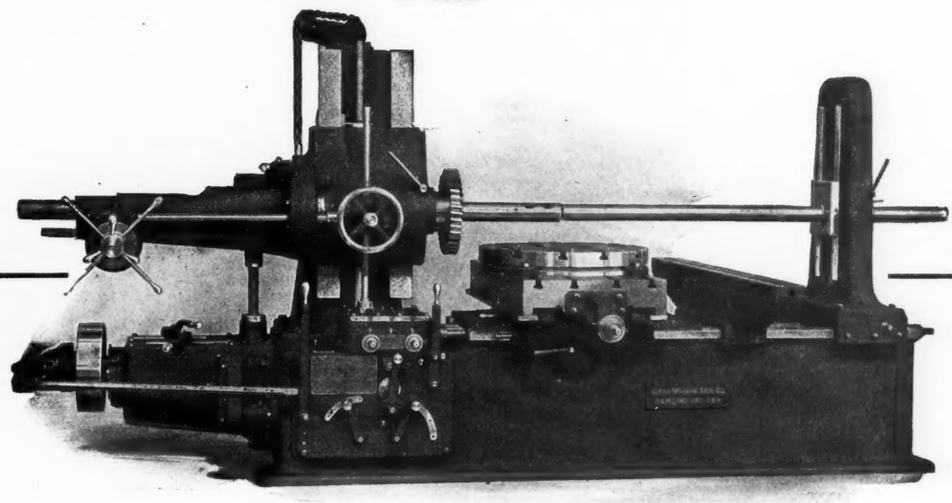
BAUSH MACHINE TOOL CO., 200 Wason Ave., Springfield, Mass., has increased its capital stock to $500,000, 6 per cent accumulative preferred stock and $1,000,000 common stock following the transfer of a controlling interest from Mr. Frank H. Page, president of the National Equipment Co., to Mr. C. K. Lassiter, mechanical superintendent of the American Locomotive Co. The company will take over the manufacture of multiple-spindle and hydro-pneumatic drills, bolt turning machines and stay-bolt threading machines, designed and patented by Mr. Lassiter. The officers of the new company are: C. K. Lassiter, president; Frank E. Bocorselski, vice-president; Walter H. Foster, treasurer; J. A. Eden, general manager; and Charles A. Smith, superintendent.

VAN DORN & DUTTON CO., Cleveland, Ohio, reports that it is receiving many orders from concerns that appreciate the high electrical and mechanical efficiency of its electrical portable tools. The McClintic-Marshall Construction Co., Pittsburg, Pa., several months ago purchased for its Panama Canal work twelve of the Van Dorn & Dutton hard service electric reamers, and later duplicated the order. The same company has recently given another order for twenty-four of the type DC-3 hard service electric reamers. The Hupp Motor Co., Detroit, Mich., recently ordered twenty-five Van Dorn & Dutton electric drills, having found them peculiarly adapted to motor car construction work. The C. R. Wilson Body Co., Detroit, Mich., has twenty-four electric drills in service, and the Haskell & Barker Car Co., Michigan City, Ind., has twenty in its new steel freight car shop.

EAGAN-ROGERS STEEL & IRON CO., has been incorporated under the laws of the state of Pennsylvania with a capitalization of $100,000. The company has acquired a five-acre tract on the Pennsylvania Railroad in the Chester district between Crum Lynne and Eddystone, Pa., and has started the erection of modern steel buildings, the contract for which was let to the McClintic-Marshall Construction Co. The men most actively interested in the company are Messrs. Daniel C. Eagan and John I. Rogers. Mr. Eagan is the son of the late Daniel Eagan and has had wide experience in this line of work, and Mr. Rogers is an engineer who was formerly with the Midvale Steel Co., and has been in consulting practice for the last few years in New York and Philadelphia. The company will specialize on forging plants; hammer, hydraulic press, and drop forging; tire and wheel rolling, etc. The plant is expected to be in active operation about March 1.

PERMANENT MANUFACTURERS EXHIBIT RAILWAY SUPPLIES AND EQUIPMENT. Karpen Bldg., 900 S. Michigan Blvd., Chicago, Ill., has been established on the twelfth floor, having an area of 26,000 square feet. Provisions have been made for additional floors should they be required. The purpose of the exhibition is to display all kinds of railway supplies. In connection with the exhibition there are large assembly and committee rooms for the use of railway associations, free of charge, and also a large club room, which, in furnishings and service, is of the highest class. The booths or display spaces are furnished by the management with all the necessary equipment for doing business, such as rugs, furniture, heat, light, janitor service,

University of Iowa



W H E N

(1) A machine is so designed that every feed has a quick power return engaged by the reverse motion of the SAME lever that engages the feed:

(2) Every feed is engaged by one lever:

(3) No feed can be engaged except the one which is selected:

(4) It is accurate enough for jig work and strong enough for any work:

(5) It is so simple that the operation of every lever is obvious:

It is a Good Machine

All these and many other good things are involved in the "PRECISION" Horizontal Boring, Drilling and Milling Machine. Ask for circular F-5.

Lucas Machine Tool Co., NOW AND ALWAYS OF **Cleveland, O., U.S.A.**

AGENTS—C. W. Burton, Griffiths & Co., London. Alfred H. Schutte, Cologne, Berlin, Brussels, Paris, Milan, Barcelona, Bilbao. Donauwerk Ernst Krause & Co., Vienna, Budapest, Prague. Overall, McCray, Ltd., Sydney, Australia. Andrews & George, Yokohama, Japan. Williams & Wilson, Montreal, Canada.

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telephone service, telegraph facilities, drinking water, etc. Exhibitors can secure compressed air, steam and electricity for power purposes in demonstrating models.

Vulcan Engineering Sales Co. has been organized and incorporated with offices in the Fisher Bldg., Chicago, and 30 Church St., New York. The company controls the entire product and will handle all sales of the Hanna Engineering Works of Chicago, Mumford Molding Machine Co. of Plainfield, N. J., and Q. M. S. Co. of New York. Further factory arrangements are under way and the Vulcan Co. will own and manufacture a number of railway special tools and equipment for shop and maintenance departments. The officers are H. K. Gilbert, president—formerly vice-president of the Buda Co.—and P. W. Gates, secretary and treasurer, now president of the Hanna Engineering Works—formerly president of the Gates Iron Works. E. H. Mumford, now vice-president and general manager of Mumford Molding Machine Co., will continue in the same position with the same duties as heretofore, and William L. Laib, vice-president and secretary of the Hanna Engineering Works, will continue in his present position with that company.

MISCELLANEOUS

Advertisements in this column, 25 cents a line, ten words to a line. The money should be sent with the order. Answers addressed to our care will be forwarded. Original letters of recommendation should not be enclosed to unknown correspondents.

AGENT WANTED IN EVERY SHOP for "Mechanics for Everybody," a new fifty-cent magazine. $1.00 worth for 50c., $2.00 worth for $1.00. Write at once. Address CAXTON BLDG., Cleveland, Ohio.

AGENTS IN EVERY SHOP WANTED to sell my sliding calipers. Liberal commission. ERNST G. SMITH, Columbia, Pa.

BOOK WITHOUT ALGEBRA.—Machinists' and Tool Makers' instructor. Limp leather, pocket-tool-box edition. 100 illustrations. Shop agents wanted. N. COVERT, Beaver Falls, Pa.

DESIGNING, DETAILING, TRACING and Blue Printing at reasonable rates. E. B. STAUFFER, Ephrata, Pa.

DRAFTSMEN AND MACHINISTS.—American and foreign patents secured promptly; reliable researches made on patentability or validity; twenty years' practice; registered; responsible references. EDWIN GUTHRIE, Corcoran Building, Washington, D. C.

ENGINEER will negotiate the sale of patents in Germany, or represent manufacturers. Address VICTOR CURSTADT, Engineer, Grossbeerenstr. 63B, Berlin, S.W., Germany.

ENGINEERING DATA for shop and drafting room. Send for monthly list. Box 191, Plainville, Conn.

FEBRUARY, 1912, Third Annual Magneto Bargain Sale. Imported High-Tension Magnetos at Less than Cost of Importation. Our third annual genuine inventory sale of U. and H. Master Magnetos, made in Germany, is now in progress. All H. P., sizes and types, for 1-, 2-, 4-, and 6-Cylinder Motors, suitable for motor cars, motor wagons, motor boats, motorcycles, stationary engines, etc. Write now, before they are all gone, for circular and price-list. The sale is a real Magneto money saver. J. S. BRETZ COMPANY, 250 West 54th Street, New York.

FOR SALE.—MODERN, UP-TO-DATE JOBBING FOUNDRY and machine shop in the best town in Oregon. Address Box 425, care MACHINERY, 49 Lafayette Street, New York.

FOR SALE.—One new 300-ton Electrically Tilted Hot Metal Mixer of latest design. Address Box 442, care MACHINERY, 49 Lafayette St., New York City.

HARDENER WANTED.—THOROUGHLY PRACTICAL MAN, experienced in heat treating, hardening and tempering carbon and alloy steels and capable of taking charge of such work. Only a man of good habits will be considered, and he must be one who is still able to learn. Address with full particulars as to experience, salary expected, etc. STEEL HARDENER, Box 447, care MACHINERY, 49 Lafayette Street, New York.

MACHINERY MEN.—An opportunity is offered a live man with a knowledge of the selling end of the machinery line to enter a business that has ended its first year in a manner highly satisfactory to its bank and its creditors. What is needed is a man who has grit and ginger enough to work sixteen hours a day for a year or so, and sufficient capital to compel his deepest interest every minute. His record must be such as to stand the most rigid investigation by Dun or Bradstreet. The business handles the general machinery lines and is located on the Northwest Pacific Coast. Address with particulars ROOM 63, EXCHANGE BUILDING, Vancouver, B. C.

MACHINISTS.—Do you want to earn a day's pay during the noon hour? We are offering big inducements to hustlers in every machine shop in the country. A bonafide business proposition. No triflers need apply. Write for particulars. ALERT TOOL CO., 221-223 N. 23rd St., Philadelphia, Pa.

MECHANICAL ENGINEER, Frenchman, age 30, partly educated in England, also well up in American methods, who has had first-class training—technical, shop, D. O. and sales—a common-sense, energetic business man, speaking and writing both French and English, also able to translate all technical matter pertaining to mechanical and electrical industries, wishes to make arrangements with sound American firm manufacturing machine tools, tools, or other mechanical appliances of a practical and original nature, who are desirous of introducing their goods in France. Write MANDAT POSTE 093, Bureau 26, Paris, France.

PATENTS—H. W. T. JENNER, patent attorney and mechanical expert, 608 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact cost. Send for full information. Trade-marks registered.

POWELL PLANER in first-class condition, 96" x 96" x 16' bed; bed 8" thick; 4 heads, 2 on the rail, 2 on the side; weight 120,000 lbs. Price F.O.B. Fort Wayne, Ind., $5500.00. Address Box 446, care MACHINERY, 49 Lafayette Street, New York.

READ ALOUD.—$100 weekly made recutting old files by our famous process. New industry. Booklet free. ACME RECUTTING FILE Co., Beaver Falls, Pa.

SMALL TOOLS.—ALFRED HERBERT, LTD., SMALL TOOL DEPARTMENT, COVENTRY, ENGLAND, having an extensive organization and a large staff of salesmen specially engaged on Small Tools in Great Britain, France, Switzerland, Japan and Italy, are open to handle good AGENCIES FOR SMALL TOOLS of all kinds, and invite correspondence with manufacturers.

SPECIAL AND AUTOMATIC MACHINERY DESIGNED AND BUILT.—Inventions developed by a firm with wide and practical experience in the construction of high-grade manufacturing equipment. Let us estimate on your requirements without obligation to you. A postal will place you in touch with our expert. WELLS & SOULIS, MECHANICAL ENGINEERS. Confidential Designers & Builders of Special Machinery. 12 East 23rd St., Madison Square, New York.

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TEST INDICATORS.—H. A. LOWE, 1374 East 88th St., Cleveland, Ohio.

TOOLMAKER FOREMAN WANTED.—15 to 25 toolmakers, model, experimental and limited manufacturing, typewriting class. State fully qualifications and experience. Address Box 450, care MACHINERY, 49 Lafayette Street, New York.

WANTED.—Agents, machinists, toolmakers, draftsmen, attention! New and revised edition Saunders' "Handy Book of Practical Mechanics" now ready. Machinists say, "Can't get along without it." Best in the land. Shop kinks, secrets from note books, rules, formulas, most complete reference tables, tough problems figured by simple arithmetic. Valuable information condensed in pocket size. Price postpaid $1.00, cloth; $1.25, leather with flap. Agents make big profits. Send for list of books. E. H. SAUNDERS, 216 Purchase St., Boston, Mass.

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WANTED.—PARTNER to finance developing and building according to my design automatic punching and tapping nut machine—one operation—small nuts. H. VOGEL, 712 N. Alma Ave., Chicago, Ill.

WANTED.—Thoroughly competent, middle-aged man, experienced in handling from one to two hundred men, for a shop close to Los Angeles, Cal., manufacturing riveted steel pipe, and doing a general light and heavy plate and tank business. Must be thoroughly conversant with modern shop methods, a master of handling men and obtaining a maximum of production at a minimum of cost. A steady position with advancement for the right man. State age, experience, references and salary expected. Address MANUFACTURER, Box 448, care MACHINERY, 49 Lafayette Street, New York.

WANTED.—MECHANICAL DRAFTSMAN, an experienced man for work in the General Drawing Office on a general line of work. A man having had experience in valve work and building construction preferred; in replying, state age and experience, and in order to save correspondence state minimum salary, which would be considered; steady employment to the right party. Address Box 451, care MACHINERY, 49 Lafayette Street, New York.

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MILLING AXIAL TEETH IN CUTTER AND REAMER BLANKS—I

Angle of Fluting Cutter in Degrees	Width of Land, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1
50	0.020	6	.....	8	0.8604	10	0.6601	12	0.5310	14	0.4400
	0.040		.....		0.8346		0.6351		0.5057		0.4155
	0.060		.....		0.8088		0.6101		0.4808		0.3917
	0.080		.....		0.7829		0.5851		0.4568		0.3690
	0.100		.....		0.7571		0.5601		0.4330		0.3460
	0.120		.....		0.7313		0.5351		0.4102		0.3238
55	0.020	6	.....	8	0.7640	10	0.5805	12	0.4634	14	0.3620
	0.040		.....		0.7408		0.5570		0.4415		0.3603
	0.060		.....		0.7167		0.5342		0.4195		0.3385
	0.080		.....		0.6928		0.5116		0.3981		0.3141
	0.100		0.9843		0.6691		0.4888		0.3767		0.2900
	0.120		0.9596		0.6454		0.4674		0.3554		0.2785
60	0.020	6	0.9774	8	0.6790	10	0.5102	12	0 4042	14	0.3811
	0.040		0.9543		0.6572		0.4893		0.3830		0.3129
	0.060		0.9312		0.6353		0.4685		0.3630		0.2940
	0.080		0.9081		0.6134		0.4479		0.3438		0.2750
	0.100		0.8849		0.5915		0.4276		0.3252		0.2565
	0.120		0.8616		0.5697		0.4076		0.3072		0.2392
65	0.020	6	0.8834	8	0.6020	10	0.4467	12	0.3504	14	0.2850
	0.040		0.8605		0.5819		0.4283		0.3325		0.2671
	0.060		0.8386		0.5617		0.4090		0.3150		0.2507
	0.080		0.8167		0.5415		0.3906		0.2977		0.2350
	0.100		0.7948		0.5213		0.3720		0.2805		0.2195
	0.120		0.7729		0.5012		0.3538		0.2636		0.2085
70	0.020	6	0.7945	8	0.5311	10	0.3875	12	0.3007	14	0.2420
	0.040		0.7738		0.5125		0.3701		0.2847		0.2271
	0.060		0.7530		0.4938		0.3530		0.2689		0.2122
	0.080		0.7322		0.4751		0.3364		0.2534		0.1980
	0.100		0.7114		0.4564		0.3200		0.2383		0.1842
	0.120		0.6907		0.4378		0.3038		0.2234		0.1708
75	0.020	6	0.7125	8	0.4045	10	0.3332	12	0.3543	14	0.2021
	0.040		0.6928		0.4474		0.3174		0.2400		0.1900
	0.060		0.6731		0.4302		0.3020		0.2262		0.1760
	0.080		0.6534		0.4130		0.2868		0.2125		0.1635
	0.100		0.6337		0.3958		0.2718		0.1990		0.1513
	0.120		0.6141		0.3787		0.2569		0.1857		0.1400
80	0.020	6	0.6939	8	0.4010	10	0.2806	12	0.2099	14	0.1640
	0.040		0.6153		0.3852		0.2770		0.1978		0.1533
	0.060		0.5967		0.3694		0.2583		0.1857		0.1426
	0.080		0.5780		0.3536		0.2396		0.1736		0.1319
	0.100		0.5594		0.3378		0.2359		0.1616		0.1211
	0.120		0.5408		0.3221		0.2123		0.1496		0.1104
85	0.020	6	0.5577	8	0.3894	10	0.2297	12	0.1667	14	0.1271
	0.040		0.5385		0.3248		0.2176		0.1563		0.1180
	0.060		0.5222		0.3098		0.2055		0.1459		0.1090
	0.080		0.5043		0.2953		0.1933		0.1355		0.1000
	0.100		0.4868		0.2811		0.1811		0.1251		0.0910
	0.120		0.4697		0.2673		0.1690		0.1148		0.0820

Contributed by George W. Burley

MILLING AXIAL TEETH IN CUTTER AND REAMER BLANKS—II

Angle of Fluting Cutter in Degrees	Width of Land, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1
50	0.020	16	0.3735	18	0.3238	20	0.2847	22	0.2550	24	0.2299
	0.040		0.3505		0.3030		0.2645		0.2347		0.2090
	0.060		0.3281		0.2820		0.2435		0.2133		0.1884
	0.080		0.3054		0.2599		0.2230		0.1920		0.1681
	0.100		0.2840		0.2378		0.2011		0.1724		0.1482
	0.120		0.2685		0.2161		0.1806		0.1526		0.1288
55	0.020	16	0.3250	18	0.2785	20	0.2448	22	0.2191	24	0.1955
	0.040		0.3026		0.2600		0.2264		0.2002		0.1780
	0.060		0.2880		0.2420		0.2090		0.1823		0.1609
	0.080		0.2640		0.2219		0.1906		0.1638		0.1439
	0.100		0.2443		0.2080		0.1721		0.1460		0.1262
	0.120		0.2252		0.1858		0.1540		0.1292		0.1084
60	0.020	16	0.2780	18	0.2395	20	0.2099	22	0.1861	24	0.1672
	0.040		0.2602		0.2230		0.1938		0.1700		0.1520
	0.060		0.2428		0.2062		0.1776		0.1543		0.1371
	0.080		0.2256		0.1891		0.1616		0.1383		0.1220
	0.100		0.2090		0.1732		0.1458		0.1233		0.1071
	0.120		0.1928		0.1578		0.1301		0.1091		0.0925
65	0.020	16	0.2380	18	0.2085	20	0.1780	22	0.1580	24	0.1401
	0.040		0.2222		0.1941		0.1635		0.1435		0.1266
	0.060		0.2066		0.1748		0.1491		0.1293		0.1138
	0.080		0.1915		0.1599		0.1354		0.1161		0.1014
	0.100		0.1770		0.1453		0.1220		0.1031		0.0883
	0.120		0.1630		0.1322		0.1088		0.0908		0.0760
70	0.020	16	0.2010	18	0.1715	20	0.1488	22	0.1312	24	0.1165
	0.040		0.1862		0.1585		0.1363		0.1190		0.1049
	0.060		0.1740		0.1462		0.1240		0.1072		0.0938
	0.080		0.1601		0.1385		0.1123		0.0956		0.0830
	0.100		0.1478		0.1310		0.1010		0.0845		0.0704
	0.120		0.1360		0.1095		0.0890		0.0735		0.0579
75	0.020	16	0.1660	18	0.1400	20	0.1200	22	0.1052	24	0.0933
	0.040		0.1542		0.1289		0.1096		0.0950		0.0836
	0.060		0.1427		0.1180		0.0993		0.0850		0.0741
	0.080		0.1313		0.1072		0.0896		0.0757		0.0650
	0.100		0.1200		0.0970		0.0800		0.0667		0.0562
	0.120		0.1092		0.0970		0.0704		0.0580		0.0480
80	0.020	16	0.1322	18	0.1103	20	0.0950	22	0.0815	24	0.0712
	0.040		0.1228		0.1015		0.0851		0.0735		0.0634
	0.060		0.1130		0.0924		0.0762		0.0654		0.0561
	0.080		0.1035		0.0836		0.0685		0.0577		0.0490
	0.100		0.0942		0.0747		0.0610		0.0508		0.0420
	0.120		0.0848		0.0660		0.0531		0.0430		0.0352
85	0.020	16	0.0991	18	0.0817	20	0.0680	22	0.0580	24	0.0498
	0.040		0.0914		0.0745		0.0615		0.0520		0.0443
	0.060		0.0837		0.0673		0.0550		0.0460		0.0388
	0.080		0.0760		0.0601		0.0485		0.0400		0.0333
	0.100		0.0683		0.0529		0.0421		0.0341		0.0279
	0.120		0.0606		0.0458		0.0357		0.0282		0.0225

Contributed by George W. Burley

MILLING AXIAL TEETH IN CUTTER AND REAMER BLANKS—III

Angle of Fluting Cutter in Degrees	Width of Land, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1
50	0.020	26	0.2095	28	0.1912	30	0.1745	32	0.1624	34	0.1508
	0.040		0.1884		0.1705		0.1547		0.1426		0.1314
	0.060		0.1681		0.1508		0.1355		0.1232		0.1126
	0.080		0.1483		0.1314		0.1164		0.1040		0.0935
	0.100		0.1288		0.1126		0.0976		0.0853		0.0749
	0.120		0.1095		0.0935		0.0785		0.0667		0.0567
55	0.020	26	0.1780	28	0.1631	30	0.1490	32	0.1382	34	0.1278
	0.040		0.1609		0.1454		0.1321		0.1219		0.1119
	0.060		0.1439		0.1280		0.1150		0.1044		0.0951
	0.080		0.1262		0.1119		0.0985		0.0880		0.0786
	0.100		0.1084		0.0951		0.0823		0.0718		0.0630
	0.120		0.0890		0.0786		0.0665		0.0566		0.0476
60	0.020	26	0.1530	28	0.1390	30	0.1270	32	0.1176	34	0.1086
	0.040		0.1371		0.1238		0.1126		0.1028		0.0945
	0.060		0.1220		0.1086		0.0984		0.0882		0.0803
	0.080		0.1071		0.0945		0.0832		0.0743		0.0667
	0.100		0.0926		0.0804		0.0694		0.0605		0.0533
	0.120		0.0784		0.0668		0.0562		0.0470		0.0402
65	0.020	26	0.1365	28	0.1156	30	0.1053	32	0.0972	34	0.0899
	0.040		0.1197		0.1025		0.0983		0.0850		0.0780
	0.060		0.1013		0.0897		0.0820		0.0735		0.0660
	0.080		0.0832		0.0779		0.0683		0.0610		0.0544
	0.100		0.0760		0.0660		0.0567		0.0495		0.0433
	0.120		0.0642		0.0544		0.0455		0.0386		0.0335
70	0.020	26	0.1048	28	0.0954	30	0.0865	32	0.0797	34	0.0731
	0.040		0.0987		0.0841		0.0761		0.0692		0.0635
	0.060		0.0830		0.0731		0.0663		0.0589		0.0536
	0.080		0.0703		0.0635		0.0556		0.0490		0.0440
	0.100		0.0578		0.0536		0.0460		0.0396		0.0348
	0.120		0.0520		0.0440		0.0368		0.0318		0.0260
75	0.020	26	0.0835	28	0.0754	30	0.0680	32	0.0623	34	0.0567
	0.040		0.0741		0.0660		0.0594		0.0538		0.0493
	0.060		0.0650		0.0567		0.0509		0.0456		0.0413
	0.080		0.0562		0.0493		0.0430		0.0377		0.0336
	0.100		0.0480		0.0413		0.0358		0.0308		0.0265
	0.120		0.0400		0.0336		0.0278		0.0233		0.0197
80	0.020	26	0.0684	28	0.0508	30	0.0509	32	0.0464	34	0.0431
	0.040		0.0561		0.0493		0.0443		0.0400		0.0360
	0.060		0.0190		0.0427		0.0379		0.0338		0.0301
	0.080		0.0421		0.0360		0.0311		0.0272		0.0245
	0.100		0.0355		0.0301		0.0257		0.0215		0.0191
	0.120		0.0288		0.0245		0.0205		0.0154		0.0141
85	0.020	26	0.0437	28	0.0365	30	0.0341	32	0.0306	34	0.0278
	0.040		0.0385		0.0337		0.0296		0.0265		0.0238
	0.060		0.0334		0.0289		0.0251		0.0222		0.0198
	0.080		0.0288		0.0241		0.0206		0.0179		0.0158
	0.100		0.0232		0.0194		0.0163		0.0187		0.0118
	0.120		0.0181		0.0147		0.0118		0.0095		0.0078

Contributed by George W. Burley

No. 152, Data Sheet, MACHINERY, March, 1912

MILLING AXIAL TEETH IN CUTTER AND REAMER BLANKS—IV

Angle of Fluting Cutter in Degrees	Width of Land, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1	Number of Teeth to be Cut	Depth of Cut, Radius = 1
50	0.020	36	0.1404	38	0.1314	40	0.1232	42	0.1164	44	0.1106
	0.040		0.1212		0.1126		0.1045		0.0976		0.0917
	0.060		0.1020		0.0935		0.0858		0.0785		0.0731
	0.080		0.0832		0.0749		0.0676		0.0603		0.0548
	0.100		0.0651		0.0567		0.0484		0.0423		0.0370
	0.120		0.0476		0.0387		0.0297		0.0248		0.0196
55	0.020	36	0.1195	38	0.1119	40	0.1044	42	0.0985	44	0.0937
	0.040		0.1034		0.0951		0.0882		0.0823		0.0773
	0.060		0.0862		0.0786		0.0724		0.0665		0.0614
	0.080		0.0702		0.0630		0.0619		0.0507		0.0460
	0.100		0.0546		0.0476		0.0416		0.0360		0.0311
	0.120		0.0393		0.0326		0.0266		0.0207		0.0163
60	0.020	36	0.1013	38	0.0945	40	0.0882	42	0.0833	44	0.0790
	0.040		0.0867		0.0804		0.0745		0.0694		0.0653
	0.060		0.0728		0.0668		0.0610		0.0562		0.0517
	0.080		0.0590		0.0533		0.0480		0.0432		0.0390
	0.100		0.0459		0.0402		0.0348		0.0308		0.0260
	0.120		0.0329		0.0272		0.0222		0.0172		0.0185
65	0.020	36	0.0885	38	0.0779	40	0.0725	42	0.0688	44	0.0647
	0.040		0.0718		0.0660		0.0611		0.0567		0.0530
	0.060		0.0596		0.0544		0.0498		0.0455		0.0420
	0.080		0.0481		0.0432		0.0388		0.0347		0.0312
	0.100		0.0372		0.0325		0.0283		0.0243		0.0210
	0.120		0.0267		0.0221		0.0180		0.0140		0.0109
70	0.020	36	0.0681	38	0.0635	40	0.0589	42	0.0556	44	0.0525
	0.040		0.0577		0.0536		0.0494		0.0460		0.0439
	0.060		0.0481		0.0440		0.0402		0.0368		0.0338
	0.080		0.0387		0.0348		0.0312		0.0275		0.0249
	0.100		0.0298		0.0260		0.0225		0.0192		0.0166
	0.120		0.0211		0.0174		0.0142		0.0111		0.0085
75	0.020	36	0.0580	38	0.0493	40	0.0456	42	0.0430	44	0.0405
	0.040		0.0444		0.0413		0.0380		0.0353		0.0330
	0.060		0.0370		0.0336		0.0307		0.0279		0.0258
	0.080		0.0296		0.0265		0.0236		0.0205		0.0189
	0.100		0.0225		0.0197		0.0169		0.0141		0.0125
	0.120		0.0160		0.0131		0.0106		0.0088		0.0064
80	0.020	36	0.0390	38	0.0360	40	0.0332	42	0.0311	44	0.0293
	0.040		0.0331		0.0301		0.0280		0.0257		0.0243
	0.060		0.0278		0.0245		0.0225		0.0205		0.0191
	0.080		0.0216		0.0191		0.0172		0.0154		0.0142
	0.100		0.0161		0.0141		0.0122		0.0104		0.0093
	0.120		0.0110		0.0090		0.0073		0.0055		0.0043
85	0.020	36	0.0253	38	0.0231	40	0.0212	42	0.0196	44	0.0183
	0.040		0.0215		0.0195		0.0178		0.0166		0.0151
	0.060		0.0177		0.0159		0.0143		0.0130		0.0119
	0.080		0.0138		0.0122		0.0108		0.0096		0.0087
	0.100		0.0100		0.0086		0.0073		0.0063		0.0055
	0.120		0.0062		0.0050		0.0039		0.0030		0.0023

Contributed by George W. Burley

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